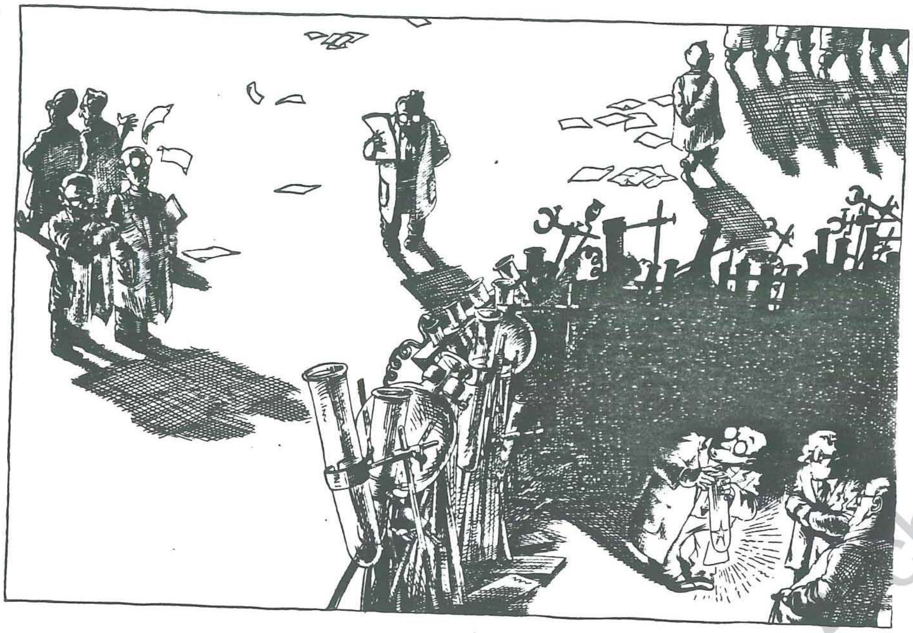


The secret life of cold fusion

PALO ALTO, CALIFORNIA, AND CAMBRIDGE, MASSACHUSETTS

Cold fusion disappeared from the public eye with striking speed, but many scientists are still working on it. The field frustrates and demoralises those who want easy certainties. At the same time it provides a fascinating example of the sort of chaos from which scientific certainties are born

SIX months ago cold fusion burst upon the world. Three months ago it had vanished from sight. The popular wisdom is that nothing was demonstrated except credulousness and sloppy experimental technique. However, a coterie of scientists, respected experimenters among them, stubbornly insist that cold fusion happens, and that it generates energy—albeit sporadically and in unpredictable amounts. Be it gullibility on a grand scale, a violation of the laws of nuclear physics, or deviant chemistry, the "cold fusion" phenomenon still needs explaining.

The number of laboratories involved has shrunk since the heady days of April. Many teams ran out of patience and money, yet believers and some sceptics struggle on. A dozen or so groups say that their apparatus produces energy. Some have found tritium, a heavy type of hydrogen that is produced by nuclear reactions, and some have spotted radiation. Others have come up with lots of reasons to doubt whether anything is going on at all.

Whatever the outcome—and it may not be known for years—the dispute has become a classic scientific controversy. Theories, reputations and money are at stake. Scientific fact has become elusive; for fusioneers, faith is essential. Every claim they make can be questioned, yet every doubt cast on them can, it seems, be shrugged off. Everything is still to play for.

The story so far

On March 23rd Dr Stanley Pons, of the University of Utah, and Dr Martin Fleischmann, of Southampton University, held a press conference to unveil a new source of energy. They were both respected practitioners of electrochemistry, the study of chemical reactions driven by electric currents. Their apparatus seemed childishly simple; a Utah fusion cell is little more than a test tube fitted with two electrodes, one of them made from the rare metal palladium. The test tube contains heavy water. Where normal water has atoms of hydrogen, heavy water has deuterium, a heavier form of the element.

The deuterium is the crux of the matter. Dr Pons and Dr Fleischmann claimed that pairs of deuterium nuclei inside or on the surface of the palladium were joining together to make heavier nuclei. This fusion process is well known to give off energy—it drives stars and hydrogen bombs. But it normally requires the nuclei, which repel each other, to be brought together with great force. The Utah claim caused uproar because Dr Pons and Dr Fleischmann claimed to be seeing fusion with un-energetic, room-temperature nuclei—hence "cold fusion".

It was clear that Utahn cold fusion broke the laws of physics. Breaking laws is the way to find better ones; it's fun to boot. Within days, the best physics laboratories in the world—as well as the second-best, and quite probably some that are no good at all—were trying their own experiments. So were the world's electrochemists. Early experimental confirmations amounted to little, especially since some were quickly followed by retractions, which of course fuelled scepticism. Dr Pons and Dr Fleischmann grew reticent, and unhelpful to sceptics.

Much of the early research was freelance, with money and equipment siphoned off from other projects. After a few months, many part-time fusioneers had to get back to the jobs they are paid for. Some new sources of money have since opened up. In America, the Electrical Power Research Institute, which raises money from the energy industry, has allocated $800,000 to research this year. According to Mr Bindi Chexal, a programme manager who oversees the institute's fusion budget, $2m will be available next year. The state of Utah, flushed with local pride, has put about $5m aside for fusion research. Japan has set up an 80-strong fusion research institute. India is devoting the resources of two of its national laboratories to fusion research. There are similar programmes in other third-world countries. Meanwhile corporations have been keeping a close eye on what is going on. Scientists from America's General Electric have been frequently spotted around the University of Utah. Some are visiting Dr Pons this week.

Alarums and excursions

The people still working on the problem—the hard-core fusioneers—have reached a degree of consensus. They believe that fusion cells can behave in more than one way. They can give off tiny amounts of tritium and a few neutrons, but no heat; they can give out steady heat for a few days; or they can give off intense bursts of heat.

The first sort of behaviour, products-without-energy, was identified by Dr Stephen Jones of Brigham Young University, also in Utah. Similar effects have been seen in numerous laboratories, including Los Alamos National Laboratory in New Mexico. No explanation for them is universally accepted, but nor is anyone unduly worried by them. If this was the only sort of cold fusion on offer it would be a minor scientific curiosity.

It is the phenomena that involve energy that arouse passions. In some laboratories, cells give off energy (in the form of heat) 10-50% faster than energy is put into them (in the form of electric current). Laboratories at Texas A&M University, Stanford in California, Utah, Florida, Minnesota, Tennessee, in Italy and in India have claimed this sort of result, to cite the most prominent.

The third type of fusion is the "heat excursion". After weeks at a steady level, the cell's temperature suddenly climbs to hitherto unapproached heights, stays there for hours or maybe a day, and then returns to normal. This sort of day-trip fusion has been seen mostly by the two independent groups in Utah. Heat excursions have an energy output up to ten times the energy input. They stop as suddenly as they start. Nobody knows why.

As well as heat, there is tritium, another type of heavy hydrogen. Two groups at Texas A&M University, one led by Dr John Bockris and the other by Dr Kevin Wolf, have detected tritium in fusion cells. With tritium and heat, one can construct an argument. If heat is being produced, it must come from somewhere. The same is true of tritium, which is radioactive and shortlived, and thus rare. A deuterium fusion reaction can produce heat and tritium, so it offers a simple explanation of the facts. Unfortunately it does not explain all the facts, it contradicts some other facts, and to accept it you must junk large amounts of atomic physics that have been gospel for 50 years.

It may be easier to get rid of the facts than try and make sense of them. There is little doubt that people are measuring tritium; but it is possible that there is tritium in the palladium before the experiment starts. Dr Wolf is now doing experiments that carefully compare the tritium in the electrodes before and after.

In the case of the heat there are some who do not believe it exists at all. The trouble lies in calorimetry, the measurement of heat. Everyone used to think calorimetry was straightforward. Now that so much rests on it, scientists have rediscovered its awkwardnesses. Dr Nathan Lewis of the California Institute of Technology has looked at some of them. The most fundamental is the calibration of the equipment. Since the amount of liquid can change as some bubbles away, the relationship between heat and temperature can change. The ramifications of this simple point make heat output hard to measure. The fusioneers' tendency to leave their cells open to the air makes matters still worse. According to Dr Lewis, no one who uses sealed cells has reported seeing heat.

Dr Walter Myerhof, also of Stanford, has tried to work out error margins for fusion-cell calorimetry. He concluded that it is reliable only to within 15-20% of the value of a given reading; enough to account for the constant low-level heat output measured by many laboratories. What then about the large energy output during heat excursions? Dr Lewis points out that such short-lived phenomena could be due to fluctuations in the chemical conditions of the experiment. The fusioneers admit that large quantities of heat sometimes get produced by such things, but claim to distinguish between these and "genuine" excursions.

Dr Lewis insists that no groups have properly shown a net output of heat over the entire length of an experiment. Remember, the cells have usually been absorbing electrical energy for long periods before giving out a burst of heat. They may be hoarding the energy away piecemeal, and then letting it all out at once. The technical term for a device that stores and releases electrochemical energy is not "fusion cell". It is "battery".

In response, fusioneers claim safety in numbers. They argue that, though errors can creep into any set of measurements, the chances are remote that a dozen different laboratories, using various types of calorimeter, should all be making the same mistakes all the time. They also point out that heat does not seem to be generated when deuterium is substituted by ordinary hydrogen. Everyone agrees that fusion is inconceivable without deuterium.

One thing that would help convince outsiders would be a fusion cell that performed on demand. At present, the cells are capricious; their unpredictability fuels doubts and prolongs investigations. One of the problems the fusioneers have had is that their experiments last far longer than the media's attention span.

According to Dr Savarian Guruswamy, who works with Dr Milton Wadsworth's team in Utah, a typical cell will see a heat excursion once or twice every couple of months. In one six-week experiment, six cells produced heat once and one of them twice. Dr Bockris's group at Texas A&M saw low-level heat in four out of eight cells over three months. All 12 cells alongside produced tritium. Dr Glen Schoessow at the University of Florida claims to have seen low-level fusion in one cell for 32 consecutive days. It was still giving out heat as this page went to press.

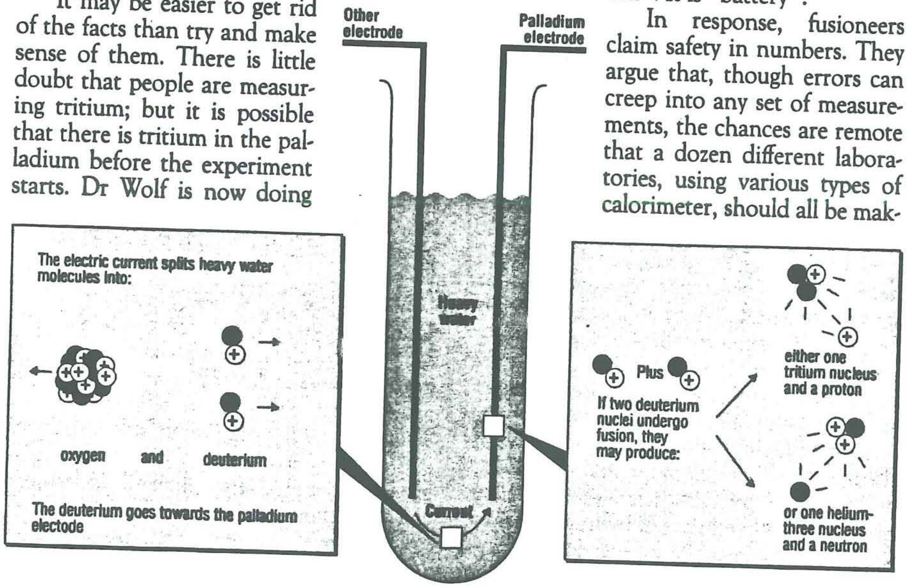
The trouble with tritium

The debate over facts takes place on the fusioneers' home ground; they control the laboratories. It may end with the gradual admission of systematic errors, or with the development of cells that can be made to start and stop working on command. Even then they will need some theoretical framework if they are to convince outsiders. That could mean forcing electrochemists to make room for new chemistry. But if they are to prove nuclear fusion is going on, it will mean fighting on the critics' home ground: theoretical physics.

Physicists find cold fusion doubly impossible; impossible because of what does happen, and impossible because of what does not happen. When two deuterium nuclei fuse in the sun, they produce either a tritium nucleus and a proton, or a rare type of helium and a neutron (see diagram). Theory predicts that both helium and tritium should be produced in roughly equal amounts. Thus, besides tritium, researchers should be able to detect light helium, neutrons, and X-rays given off by fast protons. They do not.

In one particularly damning experiment Dr Michael Solomon, a physicist at Utah, set up detectors in Dr Pons's laboratory. They ran continuously for six weeks, with the exception of a 24-hour hiatus when the university was struck by lightning. At the end of the six weeks, Dr Solomon had seen nothing, though the cells had been producing a little heat. Dr Pons told him that there had in fact been one heat excursion. It had taken place the day the detectors had been out of commission. Scientists who know Dr Pons and Dr Solomon say that relations be-

Test-tube fusion


Other electrode
Palladium electrode
Heavy water
Current
The electric current splits heavy water molecules into:
oxygen
and
deuterium
The deuterium goes towards the palladium electode
Plus
If two deuterium nuclei undergo fusion, they may produce:
either one tritium nucleus and a proton
or one helium-three nucleus and a neutron

S
To Vo
Cust
Swed
Fax:
Volvo
matic
series
☐The
THE ECON

tween the two have soured.

There is a little hope for fusioneers. The belief that tritium and helium should be produced in equal amounts stems from experience with nuclei free to collide at random. If the reaction takes place inside the palladium, as most fusioneers believe, then one set of products might possibly be favoured over another because the atoms in solid palladium are aligned in a particular way. Research by Dr Wolf and Dr P.K. Iyengar of the Bhabha Institute in Bombay suggests that this might be so. Independently, both groups measured that a fusion cell produces about ten million times as much tritium as helium. Their close agreement is far from conclusive. It is intriguing.

Dr Wolf calculates that if the Utahn cells were producing tritium at the same rate as his Texan cells, then the energy given off would account for the low-level heat seen by Dr Pons. Unfortunately the levels of tritium measured by Dr Pons are thousands of times lower than those measured by Dr Wolf, and by the team led by his colleague Dr Bockris. To make a dent in the physicists' disbelief, they need to find similar tritium levels in cells producing similar amounts of heat. They also need to demonstrate the relation between heat production, tritium and helium production, and radiation—the sort of correlation that Dr Solomon could not find in Dr Pons's laboratory.

There is a further theoretical problem with tritium. Theory predicts that the tritium created in deuterium fusion comes away from the reaction with a great deal of the energy that has been released. In fact, it has so much energy that it should react with any other deuterium nuclei it comes across. This second reaction would, in turn, produce its own characteristic products. None has been seen. Dr Wolf has calculated that if such a secondary reaction is to be avoided, then the tritium must be dumping the energy as soon as it gets it—but how and where, no one has the least idea.

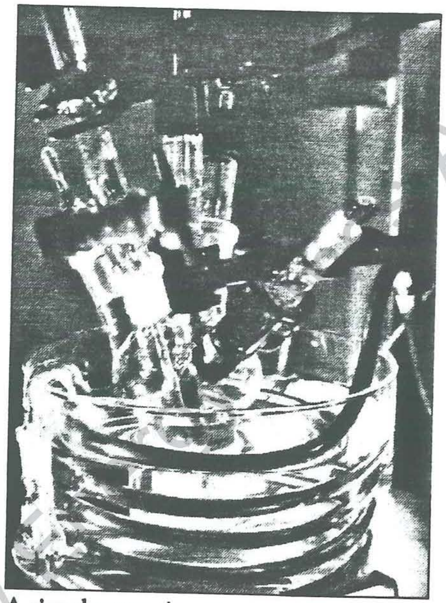
Clashing by night

Suppose the fusioneers are wrong, and the heat comes not from nuclear fusion, but from a chemical reaction. How does that explanation stand up? None too well.

The obvious chemical reaction to invoke is one between oxygen and deuterium. The electric current in the cell tears heavy-water molecules into their constituent deuterium and oxygen atoms, which takes energy. If those atoms then recombine to make water, they will release energy. So the heat might be explained by deuterium and oxygen recombining.

However, fusion cells can produce a lot of heat. After one of Dr Pons' heat excursions, his rough calculations—too rough to be accepted by his critics as reliable—showed that the cell had produced 8m joules of energy, enough to light one bar of an electric fire for a little under two hours. That much energy might have been produced if all the water molecules broken apart had recombined. But an electrochemist would expect no more than 3-5% of the separated oxygen and deuterium to recombine: not nearly enough. Dr Pons concluded that there must have been a net production of heat from the experiment—either due to a nuclear process, or some chemical reaction other than recombination. It would help his point if his calculations were more thorough.

Just as nuclear reactions leave tell-tale products, so do chemical ones, in the form of new molecules. Yet there have been no chemical changes measured in the palladium electrodes or the heavy water. In one experiment, Dr Bockris's group passed a small electrical current through the palladium to see if its resistance changed when energy was produced. A chemical change should cause a change in the resistance. None was found. Others have examined their electrodes under electron microscopes to see whether the fine details of their structure have changed, and found nothing.



A simple experiment

There is no intrinsic reason to prefer unknown chemistry to unknown physics as an explanation, and neither is satisfactory. Therein lies a good reason to reject the heat measurements: it is more sensible to reject sporadic and dubious readings than to reject well-established theories. Were it not for the presence of tritium the fusioneers would probably have given up.

Many laboratories have done so already, unable to find a thing. But absence of evidence is not evidence of absence, and negative results are as open to doubt as any others. Take Britain's Harwell Laboratory. Little work on tritium could be done there because the source of the heavy water was a nuclear reactor, which means it was inevitably contaminated by tritium. Some people at Harwell have told the fusioneers that they did see some heat and some neutrons but that the readings were low and unreliable. To those who desire certainty, that is not enough. Yet those working on new phenomena find it notoriously difficult to produce statistically significant work. And without statistical significance, it is hard to get novelty into scientific journals.

One team claims to have the results the world is waiting for. Dr Glen Schoessow and Dr John Wethington, two elderly scientists doing their research in the University of Florida's nuclear engineering department, say they can switch cold fusion on and off at will and control the amount of heat produced. Furthermore Dr Schoessow says that he has detected tritium, neutrons, and gamma radiation. He has not been able to match the rate of production of fusion by-products to the rate of heat generation.

The two scientists and their patent lawyers are playing things close to their chests. Their laboratory is barred to prying eyes; they give few details about their work. Some who have seen the experiment are impressed. They report the intriguing detail that Dr Schoessow uses button-shaped electrodes unlike those of any other fusioneer. But a fusion group downstairs in the same building has disowned the two scientists.

Is nothing sacred?

When it was unleashed on the world cold fusion was described as simple. It depended on tried and tested techniques. Measuring neutrons and radiation, while not easy, is bread and butter to nuclear physicists. Calorimetry and electrochemistry were old tame disciplines. Yet even the most standard scientific procedure is open to objection when a new phenomenon is at play. All experimenters have their own style, their own ways of doing things. When there is no controversy such differences matter not a bit. Controversy makes everything open to question.

The niceties of measurement, normally taken as read by all concerned, become vital. They are scrutinised, and scrutiny brings to light complexities normally taken for granted, which in abnormal circumstances become matters of pressing concern. Only someone with hard-won experience can defend all the details of his calorimetry, or his electrochemistry, or his nuclear physics. No-one can defend all three, since there has never before been reason to master all three. So there is indefinite room for special pleading in the gaps between the disciplines. Only time can bring a unified expertise, and the hindsight to explain the erroneous results with which the field is doubtless littered. What, if anything, will survive that scrutiny must remain to be seen.

Energy Research Advisory Board
to the
United States Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 586-5444

-R.L. GARWIN-
4 OCT 89 13.44

September 29, 1989

TO: Members of the Cold Fusion Panel

Enclosed for your information is an article from the New York Times, a Special Call for Recent New Papers on Cold Fusion, a letter from Bockris to Bigeleisen and his letter to Kevin Wolf, an article entitled "Brookhaven Chemists Induce Fusion by Putting the Squeeze on -- With Clusters", and a Memo from Bigeleisen about Cold Fusion Research at BNL.

Bill
William L. Woodard
Panel Secretary

Enclosures

092989.WLW

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper: Exploratory Experiments Concerning Anomalous Thermal Effects in the Palladium-Deuterium System

Authors (Underline name of author presenting paper.) W. A. Adams, E. E. Criddle and V. S. Donepudi, Electrochemical Science and Technology Centre, University of Ottawa, Ontario, Canada K1N 6N5; B. E. Conway and G. Jerkiewicz, Department of Chemistry University of Ottawa, 32 George Glinski, Ottawa, Ontario, Canada K1N 6N5; J. Hebert, Department of Physics, University of Ottawa, 34 George Glinski, Ottawa, Ontario,

Business affiliation and address Canada K1N 6N5; C. L. Gardner and F. Szabo, Department of National Defense, 101 Colonel By Drive, Ottawa, Ontario, Canada K1A 0K2

CANADA (State or Country)

(ZIP Code)

(613) 564-6818 (Telephone No.)

(Type abstract in this area—double-spaced.)

Electrolysis experiments (in H_2O and D_2O solvent) have been conducted to observe the anomalous thermal and possible cold fusion effects that were recently reported by Fleischmann and Pons (1). Different variables studied include: i) well-characterized palladium electrodes with differing metallurgical structures, ii) electrolyte composition, iii) cell configuration, and iv) the role of recombination. Experimental observations include: i) thermal balance by calorimetry, ii) particle emission, i.e., neutron flux and other possible products, iii) electron-optical analyses of palladium surfaces prior to and following deuterium charging, and iv) analyses of gas streams during deuterium and hydrogen charging.

(1) M. Fleischmann and S. Pons, J. Electroanal. Chem., 261, 301-308 (1989).

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper: Investigation of Phenomena Related to D_2O Electrolysis at Palladium Cathode

Authors (Underline name of author presenting paper.): R. Adzic, D. Gervasio, I. Bae, B. Cahan and E. Yeager

Business affiliation and address: Case Center for Electrochemical Sciences, Case Western Reserve University, Cleveland, OH

Ohio	44106	(216) 368-3626
(State or Country)	(ZIP Code)	(Telephone No.)

(Type abstract in this area—double-spaced.)

Measurements have been performed to check on the Fleischmann and Pons phenomenon. They involved calorimetric measurements in glass cell of the type used by Fleischmann and Pons and also a battery type "Tronac" calorimeter, determination of the D/Pd ratio by coulometry, Li determination in the electrolyte and neutron radiation measurements. Total energy balance of a closed cell obtained by "Tronac" calorimeter showed an excess heat production over an extended period for Pd in LiOD. Much smaller heat effect was found with Pd in LiOH. Heat effect was also found with the glass cell. The D/Pd ratio is 1:1 for 0.25 mm wire. Li was found at 200 nm into Pd bulk. Five-fold enhancement of tritium was found with one cell, while the neutron measurements were inconclusive.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusio
Hollywood, Florida—Octo

Algasmi

This symposium will cover all aspects of cold nuclear fusion. All contri
hence extended abstracts will not be required. The deadline for subn
1989. No paper will be scheduled unless an abstract is received on the
be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Cher
St., Urbana, IL 61801. FAX transmission can be arranged by prior tele
8306.

FAX only

Done 9/11 gw

Title of paper Neutrons and Tritium From Cold Fusion in Pd-D

Authors (Underline name of author presenting paper.) R. Alqasmi*, K. Albertsen, H.-G. Cnotka and H.-J. Schaller

Business affiliation and address Institut für Physikalische Chemie der Universität, Kiel,
F.R. Germany, *The United Arab Emirates University, Chemistry Dept, Alain
United Arab Emirates (State or Country) Post Box #15551 Alain (ZIP Code) +971-3-634644 (Telephone No.)

(Type abstract in this area—double-spaced.)

This report concerns the observation of neutrons and tritium from cold fusion in Pd loaded electrolytically with deuterium. In order to achieve high deuterium concentrations, the electrolysis was carried out at 20, 0, and -80°C, successively using an alcohol acid bath as the electrolyte, Sporadic neutron emissions significantly above the background level were observed in three long time experiments. Measurements of the tritium levels in the electrolyte solutions point to a generation of tritium.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper: A Loose Deuteron Cluster Model for Cold Nuclear Fusion

Authors (Underline name of author presenting paper.): Dr. Robert T. Bush and Dr. Robert D. Eagleton

Business affiliation and address: Physics Department, California State Polytechnic University,
Pomona, 3801 West Temple Avenue, Pomona
California (State or Country) 91768 (ZIP Code) (714) 869-4018 (Telephone No.)

(Type abstract in this area—double-spaced.)

A loose deuteron cluster model (stoichiometries around 1) is presented to attempt to account for cold nuclear fusion. The model accounts for "anomalies" observed in the production of excess heat, neutrons, and tritium.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

RECEIVED AUG 07 1989

Title of paper: Attempts to Observe Cold Fusion in Pressure and Electrochemical Experiments

Authors (Underline name of author presenting paper.): M. A. Butler, D. S. Ginley, J. E. Schirber, and R. I. Ewing

Business affiliation and address: Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM (State or Country) 87185 (ZIP Code) (505) 844-8863 (Telephone No.)

(Type abstract in this area—double-spaced.)

The apparent discovery of cold fusion at low levels by Jones and other workers has excited tremendous attention. Neutron production near the background level is difficult to confirm. We report underground experiments with electrochemical cells and pressure bombs simultaneously utilizing three neutron detectors (background 10±1 counts summed over all three detectors). No coincident events have been observed in all three detectors (with appropriate relative intensities) in over 500 hours of run time.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper: Search for Evidence of Cold Fusion by Radiation Detection and Calorimetry

Authors (Underline name of author presenting paper.): E. Darcy, D. Young, G. Badhwar, and A. Konradi

Business affiliation and address: NASA-Johnson Space Center/EP5, Houston, TX 77058

Texas (State or Country) 77058 (ZIP Code) (713) 483-9055 (Telephone No.)

(Type abstract in this area—double-spaced.)

Two experiments to verify cold fusion are presented. First, with sensitive radiation detectors, no levels above background were found in vented cells containing 0.1 M ^{6}LiOD with three Pd geometries through weeks at 500 mA/cm^{2}. Second, precise heat balances are being performed on closed cells with recombination with a high power (20W) heat conduction calorimeter from Hart Scientific, Inc. Cell design and charging sequence are per the proportions and advice of previous work claiming excess heat. Details or apparatus, procedures, and analysis of results will be presented.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper: Cold Nuclear Fusion Research at Cal Poly Pomona: Some Preliminary Data

Authors (Underline name of author presenting paper.) Dr. Robert T. Bush[1], Dr. Robert D. Eagleton[1], and James F. Stephenson[2]

Business affiliation and address: 1. Physics Department 2. Chemistry Department (Research Associate) - California State Polytechnic University, Pomona, 3801 West Temple Ave. Pomona, CA

(State or Country) 91768 (ZIP Code) (714) 869-4019 (Telephone No.)

(Type abstract in this area—double-spaced.)

California state Polytechnic University, Pomona, has begun an experimental effort on cold fusion and preliminary results should be available by conference time. The production of heat and tritium will be checked for a variety of charging currents (above and below 1A) sample masses (1 to 15g), and sample geometries. An attempt will also be made to monitor the emission of neutrons and to detect excess He^4.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper: Effect of Microstructure on the Incorporation of Deuterium into Palladium

Authors (Underline name of author presenting paper.): J. W. Fleming, H. H. Law, P. K. Gallagher, J. Sapjeta, D. Loiacano, and W. F. Marohn

Business affiliation and address: AT&T Bell Laboratories, Murray Hill, NJ

NJ (State or Country) 07974 (ZIP Code) (201) 582-4479 (Telephone No.)

(Type abstract in this area—double-spaced.)

The effect of microstructure of palladium wires on the incorporation of deuterium was studied by comparing the behavior of annealed and cold-worked samples. Deuterium loading induced greater volume change of the cold-worked samples over the annealed ones. The rate of deuterium loading is also faster in the cold-worked wires.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

LA-UR-89-2917

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

: symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; :e extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 9. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should ubmitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-6.

: of paper Experiments In Search of Nuclear Reactions and "Excess Heat" In Metal Deuterides

hors (Underline name of author presenting paper.) S. Gottesfeld, R. E. Anderson, D. A. Baker, C. R. Derouin, F. H. Garzon, C. A. Goulding, M. W. Johnson, E. M. Leonard T. E. Springer, and T. Zawodzinski

iness affiliation and address
Los Alamos National Laboratory
MEE-11, MS D429
Los Alamos, NM 87545 (505) 667-0853
(State or Country) (ZIP Code) (Telephone No.)

(Type abstract in this area—double-spaced.)

perinents In Search of Nuclear Reactions and "Excess Heat" in Metal Deuterides, S. ttesfeld, R. E. Anderson, D. A. Baker, C. R. Derouin, F. H. Garzon, C. A. Goulding, W. Johnson, E. M. Leonard, T. E. Springer, and T. Zawodzinski. Los Alamos National iboratory

: have investigated claims of nuclear reaction phenomena in low-temperature metal :uterides by monitoring Pd-D electrolysis cells and Ti-D high-pressure vessels with :gh efficiency ^{3}He and NE-213 neutron detectors in a very low background radiation ivironment and by calorimetry in a custom-designed differential heat flux .lorimeter. Neutron emission was investigated using a multiple detector configuration th cross-correlation between individual detectors. No above- background iltiple-detector-correlated events were measured in several weeks of monitoring five fferent Pd-D electrolysis cells or LN$_2$-quenched Ti-D pressure vessels. The .lorimetric experiments measured the total heat flux from a Pd-D electrolysis cell ntaining a recombination catalyst, which allows for the collection of enthalpic data . a closed system. No energy flux above the input power was observed to date.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper A Flow Calorimeter Used in Duplication of "Cold Fusion"

Authors (Underline name of author presenting paper.) N. Huang*, Q.H. Gao*, B.Y. Liaw*; B.E. Liebert**

Business affiliation and address * Hawaii Natural Energy Institute, ** Department of Mechanical
Engineering, University of Hawaii at Manoa, 2540 Dole Street
Honolulu, Hawaii (State or Country) 96822 (ZIP Code) 808-948-6474 (Telephone No.)

(Type abstract in this area—double-spaced.)

A flow calorimeter was used to measure the excess heat in a Pons-Fleischmann-type "cold-fusion" cell with arc-melted 99.9% Pd as cathode in 0.1M LiOD-D_2O (99.9%) electrolyte. The heat rate was derived from the temperature difference of a steadily circulating water flow between the inlet and outlet of a Dewar flask. Excess heat generation was observed after 30 days of operation.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper: Comparison of Thermal Measurements on Two Fast Mixed-Conductor Systems: Deuterium and Hydrogen in Palladium

Authors (Underline name of author presenting paper.): Steven Crouch-Baker, Turgut M. Gür, George Lucier, Martha Schreiber, and Robert A. Huggins

Business affiliation and address: Department of Materials Science & Engineering
Stanford University, Stanford, CA

California	94305	(415) 723-4110
(State or Country)	(ZIP Code)	(Telephone No.)

(Type abstract in this area—double-spaced.)

Fleischmann and Pons reported that they had observed excess heat generation, neutron and gamma ray emission, and the presence of tritium in electrochemical experiments in which deuterium had been inserted into palladium electrochemically (1). They claimed that this could not be explained by any known chemical or electrochemical effect, and proposed the existence of an hitherto unrecognized form of atomic fusion related to the presence of deuterium inside palladium.

A number of experiments have been undertaken using isoperibolic calorimetry to study the electrolysis of the deuterium-palladium and hydrogen-palladium systems, employing experimental conditions as comparable as possible in order to reduce the possibility of thermal influences due to chemical or metallurgical effects. The results of these measurements, as well as some pertinent experimental considerations involved in the measurement of thermal effects in systems of this type will be presented.

1. M.Fleischmann and S. Pons, J. Electroanal. Chem. 261. 301 (1989)

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

The Electrochemical Society

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper: Observation of Neutrons from Cold Nuclear Fusion

Authors (Underline name of author presenting paper.): John N. Harb, William G. Pitt, Douglas N. Bennion, E. Paul Palmer, J. Bart Zirr, Gary L. Jensen, Steven E. Jones

Business affiliation and address: Chemical Engineering and Physics Departments,
Brigham Young University, Provo, UT 84602

Utah	84602	(801) 378-2749
(State or Country)	(ZIP Code)	(Telephone No.)

(Type abstract in this area—double-spaced.)

Sensitive neutron detectors were used to investigate cold fusion in two types of electrochemical cells. Low-level bursts of neutrons above background were observed in cells with concentric palladium electrodes. There was no evidence for excess heat or tritium production, although the expected heat generation rates were near the sensitivity limit of the cell. An additional cell capable of very high current densities did not show any measurable evidence of fusion at current densities up to $220 /cm^2$. Alternate electrode designs and electrolyte compositors have and are being tested, but with no positive results as of this writing. A non-electrochemical system has yielded tentative results of neutron bursts with D_2O prepared Portland cement.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

The Electrochemical Society

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper Search For cold Fusion of Deuterium In Palladium

Authors (Underline name of author presenting paper.) Jacob Jorne* and Jan Toke#

Business affiliation and address *Department of Chemical Engineering, #Department of Chemistry
University of Rochester
Rochester, New York (State or Country) 14627 (ZIP Code) (716)275-4584 (Telephone No.)

(Type abstract in this area—double-spaced.)

Attempts are being made to identify fusion products during the loading of palladium with deuterium. Palladium is being charged with high quantities of deuterium by two methods: (1) Electrolysis of heavy water. (2) Pressurizing palladium in deuterium gas at low temperatures. Effects of current density, temperature, surface and catalytic activities and pretreatment are being studied by positioning neutron counters around the cell to monitor an excessive high energy neutrons and γ-radiation, beyond the background level.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

ews Papers;
ptember 1,
racts should
'. California
it 217-333-

osium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by phone contact with L. R. Faulkner at 217-333-8306.

f "Electrochemically Induced Nuclear Fusion of Deuterium"-
t.

Jow →

nting paper.) T.R. Jow, E. Plichta, C. Walker, S. Slane, and
S. Gilman

Army Electronics Technology and Devices Laboratory
LABCOM, Power Sources Division, Fort Monmouth
New Jersey (State or Country) 07703-5000 (ZIP Code) (201) 544-3630 (Telephone No.)

No.)

(Type abstract in this area—double-spaced.)

ro-

erium

s

gy

ter

ischmann and Pons[1] reported that nuclear radiation and excess heat were erved when deuterium atoms were forced into a cathodically polarized ladium electrode. We have been conducting experiments to attempt to verify caloric claims under similar electrochemical conditions, but utilizing a duction calorimeter rather than the quasi-adiabatic instrumentation of the ginial investigation. The palladium cathodes were wires which were jected to a variety of metallurgical and surface treatments. Control eriments were run using Pd/LiOH, H_2O and Pt/LiOD, D_2O electrodes. Thus far, controls and all other experiments have yielded caloric outputs which are close agreement with simple theory excluding significant "excess" heat.

Fleischmann and S. Pons, Electrochemically Induced Fusion of Deuterium, J. Electroanal. Chem., 1, 301 (1989).

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers

Cold Fusion

Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper: Neutron-induced chain-reaction processes for electrolysis with metal deuterides

Authors (Underline name of author presenting paper.) Yeong E. Kim

Business affiliation and address: Department of Physics
Purdue University
West Lafayette, Indiana (State or Country) 47907 (ZIP Code) (317)494-3042 (Telephone No.)

(Type abstract in this area—double-spaced.)

Tritium production and excess heat generation observed by Fleischman, Pons and Hawkins (FPH) and others in electrolysis experiments cannot be explained by known single-step nuclear reactions such as cold deuterium fusions, since the reaction cross-sections and rates are too small at room temperature. However, a combination of known nuclear reactions can form a set of closed chain reactions which can become self-sustaining at a critical stage under favorable conditions and geometries, as in the well-known case of neutron-induced fission chain reactions. The FPH effect is described in terms of chain-reaction processes involving (1) neutron-induced fission-fusion chain reactions and (2) neutron-induced photonuclear chain reactions in palladium deuteride. Experimental evidence and tests of each hypothesis for the FPH effect are described.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper: Experiments in Search of Electrochemically Induced Cold Fusion

Authors (Underline name of author presenting paper.): Uziel Landau, W.M. Lynes, David Roha, Reenu Saini and Sarah Rochel-Landau

Business affiliation and address: Case Western Reserve University, Chemical Engineering Department, A.W. Smith Building, Cleveland, OH

Ohio (State or Country) 44106 (ZIP Code) (216) 368-4132 (Telephone No.)

(Type abstract in this area—double-spaced.)

Calorimeric measurements, tritium balances and neutron counts in electrochemical cells with deuterium charged palladium cathodes are reported. Control experiments in similar cells but with H_2O-LiOH electrolyte are also provided. Data analysis shows that although a number of the deuterium charged experiments indicate excess power, the signal to noise ratio is too low to unambiguously prove the presence of a non-conventional energy source. A greatly improved experimental system with significantly better accuracy and sensitivity is being designed and will be described.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper Calorimetric Studies of Electrochemical Incorporation of Hydrogen Isotopes into Palladium

Authors (Underline name of author presenting paper.) J. W. Fleming, H. H. Law, J. Sapjeta, P. K. Gallagher, and W. Marohn

Business affiliation and address AT&T Bell Laboratories, Murray Hill, NJ

NJ (State or Country) 07974 (ZIP Code) (201) 582-4479 (Telephone No.)

(Type abstract in this area—double-spaced.)

The formation of palladium hydride and deuteride by electrolysis has been studied with high precision calorimetry using sealed cells with in-situ recombination of gaseous products as well as open cells. Palladium electrodes prepared by different methods were studied. No unexpected excess heat was observed. The error in the energy balance is estimated to be less than 2%.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper Diffusion of Deuterium in Palladium

Authors (Underline name of author presenting paper.) H. H. Law, P. K. Gallagher, J. Sapjeta and R. Stoffers

Business affiliation and address AT&T Bell Laboratories, Murray Hill, NJ

NJ (State or Country) 07974 (ZIP Code) (201) 582-4479 (Telephone No.)

(Type abstract in this area—double-spaced.)

The diffusion of deuterium in palladium foil has been investigated using an electrolytic cell coupled with a mass spectrometer. Diffusion flux is found to be significantly higher when the deuterium content is above 0.4, presumably when the Pd deuteride is essentially all in the beta-phase. A model for the diffusion mechanism is proposed.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper Electrolysis of LiOD in a Sealed Cell

Authors (Underline name of author presenting paper.) J. McBreen

Business affiliation and address Department of Applied Science, Brookhaven National Laboratory, Bldg. 801, Upton,

New York (State or Country) 11973 (ZIP Code) (516)282-4513 (Telephone No.)

(Type abstract in this area—double-spaced.)

The electrolysis of 1 M LiOD was investigated in a cell with a Pd foil (20 mm x 40 mm x 25μ) cathode and a 100 mesh Pt anode. The cell was built like a conventional alkaline electrolyser with an asbestos diaphragm and was run at 1 Amp in a cell containing 120 ml of electrolyte. Sealed operation over a four month period was achieved using a fuel cell electrode to recombine the gases. Measurements included cell voltage, electrolyte temperature and tritium content of the electrolyte. The effect of anions on the entry and egress of hydrogen in Pd was investigated separately. These results will also be presented.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper: Calorimetric and Kinetic Observation of D_2-Pressurized LiOD/D_2O/Pd Cells

Authors (Underline name of author presenting paper.): Michael C.H. McKubre, Stuart I. Smedley, Francis L. Tanzella and Robert D. Weaver

Business affiliation and address: SRI International, 333 Ravenswood Avenue, Menlo Park, CA

CA (State or Country) 94025 (ZIP Code) (415) 859-3868 (Telephone No.)

(Type abstract in this area—double-spaced.)

Thermal and electrochemical kinetic processes were examined in a cell compromising a Pd cylindrical cathode, concentric Pt coated Ni anode, containing 0.1N LiOD in D_2O. Experiments were performed using an electrochemical overvoltage to load deuterium into the Pd lattice, at a cell voltage below that of electrolysis of D_2O, in an overpressure of D_2 gas.

Results will be described of anomalies in both the thermal behavior evidenced by the calorimetric response, and the kinetic behavior obtained from the interfacial impedance, measured as a function of D_2 loading, as inferred from axial resistance measurements of the Pd electrode.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper: An Electrochemical Calorimetric Search For Evidence of Cold Fusion

Authors (Underline name of author presenting paper.) M. H. Miles, K. H. Park and D. E. Stilwell

Business affiliation and address: Chemistry Division, Research Department
Naval Weapons Center, China Lake
California (State or Country) 93555 (ZIP Code) 619-939-1652 (Telephone No.)

(Type abstract in this area—double-spaced.)

Two different types of calorimetric cell designs were used in this attempt to detect excess enthalphy during the electrolysis of $LiOD/D_2O$ using Pd cathodes. Control experiments were run side-by-side using water in place of D_2O, Pt cathodes in place of Pd, or by reversing the direction of the cell current. No significant differences were detected between the Pd/D_2O cells and the controls. For example, in one series of experiments the ratio of heat out to Joule heat in was 1.00±0.04 for one type of calorimetric cell using a Pd cathode in $LiOD/D_2O$. For the other type of calorimetric cell, this ratio was 1.065±0.04 in $LiOD/D_2O$ compared to 1.075±0.07 in $LiOH/H_2O$. Studies on different sources of Pd are in progress.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Approved for public release; distribution is unlimited.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper Anomalous Heat Production on Electrolyzing Heavy Water Solutions of Lithium Deuteroxide with Palladium Cathodes

Authors (Underline name of author presenting paper.) A. John Appleby, Young J. Kim, Oliver J. Murphy, and Supramaniam Srinivasan

Business affiliation and address Center for Electrochemical Systems and Hydrogen Research, Texas Engineering Experiment Station, Texas A&M University, College Station,

Texas (State or Country) 77843-3577 (ZIP Code) (409) 845-8281 (Telephone No.)

(Type abstract in this area—double-spaced.)

Electrolysis of heavy and light water solutions of lithium and sodium deuteroxide have been carried out for extended periods of time using palladium cathodes of various sizes and geometrical shapes. For palladium cathodes in light water solutions, and platinum cathodes in heavy water solutions, no anomalous heat fluxes were measured using a Tronac microcalorimeter. However, for palladium cathodes in lithium deuteroxide-containing heavy water solutions, of various lithium isotope compositions, anomalous heat fluxes were measured by the calorimeter. Anomalous heat production rates were quenched, or considerably reduced, on exchanging sodium deuteroxide solutions for lithium deuteroxide solutions. Liquid scintillation counting analysis performed on heavy water solutions, after measuring anomalous heat production rates, gave only background levels for tritium in solution. Similarly, analysis for helium isotopes in bulk palladium cathodes (after the evolution of anomalous heat) corresponded to background levels.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

The Electrochemical Society

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper Energy Effects During the Electrolysis of D_2O with Pd and Pt Electrodes

Authors (Underline name of author presenting paper.) V.C. Noninski, C.I. Noninski

Business affiliation and address Laboratory on Electrochemistry of Renewed Interface (LEPGER), P.O. Box 9, Sofia 1504, Bulgaria

Bulgaria (State or Country) (ZIP Code) (Telephone No.)

(Type abstract in this area—double-spaced.)

Calorimetric experiments are carried out while the electrolysis of D_2O using Pt and Pd electrodes is taking place. It was found out that more energy is being produced than the energy spent for the process. This fact is a confirmation of a similar energy effect, firstly discovered by Fleischmann and Pons. The analysis made of the effect leads to the conclusion that no other explanation can be given for now than the initial proposition made by Fleischmann and Pons that it is due to nuclear fusion.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

ymposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should mitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California bana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-

: extended
scheduled
r: Larry R.
rranged by

6-6226

re
le
OH,
n
1

' paper Calorimetric Measurements of Anomalous Power Produced by Cathodic Charging of Deuterium into Palladium

s (Underline name of author presenting paper.) R. A. Oriani, J. C. Nelson, S. K. Lee and J. H. Broadhurst

ss affiliation and address Department of Chemical Engineering and Materials Science and
partment of Physics and Astronomy, University of Minnesota, Minneapolis,

Minnesota	55455	(612) 625-4048
(State or Country)	(ZIP Code)	(Telephone No.)

(Type abstract in this area—double-spaced.)

Seebeck-effect calorimetry on the cathodic charging of deuterium into ladium has confirmed that excess power is produced whereas it is not duced with hydrogen. With appropriate experimental parameters the excess ver can be higher than 50 watts per cm^3 Pd, and the integrated excess power amount to more than 2.2 MJ/cm^3 Pd over eleven hours. Such magnitudes very difficult to rationalize in terms of chemical reactions. At present have no evidence of nuclear reactions.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

The submitted manuscript has been authored by a contractor of the U. S. Government under contract No. W-31-109-ENG-38. Accordingly, the U. S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U. S. Government purposes.

Title of paper Electrochemical and Calorimetric Investigations of the Pd-D System

Authors (Underline name of author presenting paper.) L. Redey, K. M. Myles, D. Dees, M. Krumpelt, and D. R. Vissers

Business affiliation and address
Electrochemical Technology Program
Chemical Technology Division
Argonne National Laboratory
9700 South Cass Ave., Argonne, IL 60439-4837 (312) 972-4518
(State or Country) (ZIP Code) (Telephone No.)

(Type abstract in this area—double-spaced.)

The purpose of these experiments was to investigate the energetics of the electrochemical formation of Pd-D and Pd-H systems and to find those conditions of cell operations that may produce excess heat useful for energy production. We have performed two series of experiments: (1) differential comparison of temperature deviations between $(H_2)PdH_y/LiOH$ saturated $H_2O/Pt(O_2)$ and $(D_2)PdD_x/LiOD$ saturated $D_2O/Pt(O_2)$ cells and (2) calorimetric measurements of $(D_2)PdD_x/LiOD$ saturated $D_2O/Pt(O_2)$ cells under varying electrochemical conditions. The D/Pd ratio was monitored during the investigation. Effect of current density and duration of electrolysis on heat generation, value of x, gas recombination, electrode potential, and current efficiency were investigated. No excess heat was observed in long duration experiments within the substantial high sensitivity (13 mW/cm^2 area of Pd) and precision limits of the specially designed constant heat-loss-rate calorimeter.

Please specify audiovisual equipment other than 35 mm slide projector or overhead projector.

Special Call for Recent News Papers
Cold Fusion
Hollywood, Florida—October 15-20, 1989

This symposium will cover all aspects of cold nuclear fusion. All contributions will be handled as Recent News Papers; hence extended abstracts will not be required. The deadline for submission of 75-word abstracts is September 1, 1989. No paper will be scheduled unless an abstract is received on the standard form by September 1. Abstracts should be submitted directly to the Organizer: Larry R. Faulkner, Dept. of Chemistry, University of Illinois, 1209 W. California St., Urbana, IL 61801. FAX transmission can be arranged by prior telephone contact with L. R. Faulkner at 217-333-8306.

Title of paper: In-Situ Measurements of the H(D) Thermodynamic Activity and Stoichiometry in Pd During Electrolysis

Authors (Underline name of author presenting paper.): Philip Ross and Harvey Sokol

Business affiliation and address: Materials and Chemical Sciences Division
Lawrence Berkeley Laboratory
Berkeley, CA 94720 (State or Country) (ZIP Code) (415) 486-6226 (Telephone No.)

A variation of the classic experiments on Pd charging by Frumkin[1] were performed in alkaline electrolytes. Membrane potentials were measured using Pd diffusion tubes having a strain gauge and reference electrode sealed in the "backside" (zero current) of the tube. Frontside (current carrying) and backside potentials and inner hydrogen (deuterium) pressures were measured in 1M KOH(D) and LiOH(D). In KOH, the backside potentials were identical to those reported by Frumkin[1] in 1M H_2SO_4, e.g. $\eta = 42$ mV or $p_{22} = 21.5$ atm, corresponding to a Pd/H stoichiometry of 0.82 ± 0.02. This activity and stoichiometry was independent of current density, even for current densities as high as 1 A/cm^2. In KOD, the maximum stoichiometry was slightly lower, 0.78 ± 0.02. In LiOH(D), very different behavior was observed for the frontside potentials, which became very cathodic ($\eta = 1000$ mV) at high current density without any corresponding change in the backside potential. Post-mortem analysis of the Pd cathode surface by RBS revealed penetration of Li into the surface region (1–10 µm) during electrolysis at high current density. It is suggested that Fleischmann et al.[2] misinterpreted very negative Pd cathode potentials as indicating very high H(D) activity, which our measurements indicate is not the case.

[1] A. Frumkin and N. Aladyalova, Acta Physicochim. USSR 19, 1(1944)

[2] M. Fleischmann, S. Pons and M. Hawkins, J. Electroanal. Chem. 261. 301(1989)

[illegible]

StonyBrook

Department of Chemistry
State University of New York at Stony Brook
Stony Brook, New York 11794-3400
(516)-632-7905
BITNET: JBIGELEI@SBCCMAIL
FAX: 516-632-7960

MEMORANDUM

Date: 29 August 1989

To: File

From: Jacob Bigeleisen JB

Subject: Cold Fusion Research at BNL

On 17 August 1989 I gave a summary lecture of the Interim Report of the ERAB Cold Fusion Panel at BNL. I was invited to visit one of their research efforts in cold fusion. The work is being done by Harold ("Bud") Wiesmann.

Wiesmann has done calorimetry and is now doing experiments looking for tritium. His calorimetry experiments are not sophisticated. He operates a number of cells, each containing 100 ml. of 0.1 M or 0.5 M LiOD in D_2O. Temperature is measured with a simple mercury thermometer and the cooling bath is the air flow through the hood, where the cells are located. Thus the bath temperature is good to ± 1°C. His cells therefore operate at significant temperature differentials with respect to the ambient air. He sees no excess heat within about 6%. Even with these experiments it is possible to see that plots of ΔT vs. applied power are not linear. The quadratic term has a negative sign, showing that the heat transfer coefficient increases with temperature.

In all the calorimetric and tritium experiments a set of five cells surround a BF_3 counter which is imbedded in a protium rich shield to slow down neutrons. No neutrons above background were detected.

In the first series of tritium measurements 100 ml. of 0.1M or 0.5M solution was reduced to 40 ml by electrolysis. The cathode and anode were both platinum wire. This was a control experiment to get a rough value of the electrolytic separation factor. The T content of the D_2O increased from 2.58×10^{-4} μcuries/ml (482 dpm/ml.) to 3.74×10^{-4} μcuries/ml (573 dpm/ml.). This corresponds to a separation factor, $k_D/k_T = \beta$, of 1.68. The temperature is not known, but is above room temperature. This separation factor can be converted to a k_H/k_D separation factor and is 3.67. The latter is a typical H/D separation factor on platinum cathodes when the hydrogen gas equilibrates with the water. It is a reasonable control experiment, with the caveat that the electrolytic separation factor depends on the type of cathode, inter alia.

The second series of experiments involves a Pd cathode. In these experiments in which six cells were operated, the cells started with 100 ml. of 0.1 M or 0.5M LiOD. There were a total of 150 ml. of D_2O added during the electrolysis. Thus the volume reduction factor is the same as in the first series, but the enrichment process is different. With each addition there is a dilution of the T that has been enriched in the D_2O by electrolysis (or produced by cold fusion) with the stock T in the D_2O solution. In this series of experiments the overall separation is 3.43/2.17 = 1.58 compared with 1.45 in the first series using the Pt cathode. The D_2O in this series of experiments comes from a different drum at BNL. (2.17 vs. 2.58 x $10^{-4}\mu$curies/ml). The larger enrichment of tritium in the case of the Pd cathode vs. the Pt cathode is consistent with a larger electrolytic separation factor in the former case. Without additional work it does not provide evidence for the production of a small amount of tritium by a nuclear process within or at the surface of the palladium electrode.

The third series of experiments is currently in progress. In these experiments the off gas, $D_2 + O_2$ are recombined over a platinum catalyst (not quantitatively) and the tritium activity of the reformed water is measured. The experiments are currently in progress, but definitely show that the $DT/D_2(g)$ is depleted in tritium compared with the starting liquid D_2O. This confirms the fractionation of T at a palladium cathode during the electrolysis of D_2O. In due course these experiments should yield an independent value for β in the electrolysis of D_2O at a palladium cathode.

Distribution: ERAB panel
H. Wiesmann (BNL)

StonyBrook

Department of Chemistry
State University of New York at Stony Brook
Stony Brook, New York 11794-3400
(516)-632-7905
BITNET: JBIGELEI@SBCCMAIL
FAX: 516-632-7960

20 September 1989

Professor Kevin Wolf,
Cyclotron Institute,
Texas A & M University,
College Station, Texas 77843-3366

Dear Kevin,

I am preparing the section on "TRITIUM" for the final ERAB Panel report on cold fusion. I have reports from Bockris and Martin at Texas A & M on their tritium work. I understand that you have also made some tritium measurements on your own. If so, would you kindly complete the attached questionnaire which has been prepared by the panel and circulated by the chairman, Prof. John R. Huizenga.

For those few cases where people have observed tritium I am trying to estimate the secondary neutron production from the well known D + T reaction. For this purpose could ypou furnish me with the following information concerning your neutron measurements:

1. volume of D_2O in cell
2. neutron counter efficiency
3. counter geometry factor
4. neutron counting rate (including those cells that gave tritium and those that did not.

I would appreciate a prompt response. Thank you.

Jacob Bigeleisen

Jacob Bigeleisen

xc: W. Woodard

TEXAS A&M UNIVERSITY
DEPARTMENT OF CHEMISTRY
COLLEGE STATION, TEXAS 77843-3255

(409) 845-2011
FAX (409) 845-4719

September 7, 1989

Professor Jacob Bigeleisen
State University of NY at Stony Brook
Chemistry Department
Stony Brook, NY 11794-3400

Dear Professor Bigeleisen:

Thank you for your recent letter concerning the tritium production observed at palladium during the cathodic evolution of deuterium for D_2O-LiOD.

The concept that some person has added tritium to our samples is a suggestion inconsistent with the widespread observation of tritium under similar circumstances in various laboratories throughout the world (see addendum).

Likewise, your suggestion that the results we have obtained are due to contamination is inconsistent with the exceedingly thorough and insistent investigation of every article which has been utilized in the investigations, including an examination of the glass, rubber tubing and stoppers used in the equipment, etc., and finally with the double testing of the electrodes used for tritium content, both by an electrochemical method here, and by thermal methods at Los Alamos.

The tritium would be present as DT, and in equilibrium with DT in the gas phase. Exchange of DT with water is slow and all T would be readily removed from the liquid, after a burst (It declines ~10x in a few hours (Direct experiment).

As frequent examination for tritium of the systems being electrolyzed over months is not practiced, many investigators may have missed tritium produced in their cells.

I do not understand the relevance of your reference to the work of Farkas, 1937. He measured the H/D separation factor.

We have measured the D/T separation factor, as has also Corrigan at General Motors. It is 2 ± 0.3.

Under the conditions which we have used (topping up the cells with D_2O on a daily basis so that the total volume remains constant), we calculate (cf. enclosure) that the largest possible increase in T is equal to the separation factor, i.e.,

$$C_{T,t}/C_{T,0} = S - (S-1)e^{-t/T}$$

I am astounded to learn that you think that the questions concerning the heat production have been substantially clarified. I am in touch with many people obtaining positive results on "cold fusion", and none of them understand the origin of the Heat Bursts. Why do you think they occur?

We are clearly in the first few months of the investigation of the new field of nuclear electrochemistry. I invite you to compare your statement that "bursts of 100 neutrons have no practical implications" to that made by Rutherford at the beginning of the nuclear period in chemistry.

Electrochemical confinement has attained the goal of fusion physics: sustainment. Whether, it will be significant for energy production is an open question decidable in a time inversely proportional to the budget give to research it.

I make two general observations:

1) The phenomena being observed are difficult to investigate because they occur only sporadically and irreproducibly.

The first requirement seems to be very long electrolyses, between 10 and 100 days at high current densities (thus eliminating investigations where the investigators presumably thought they might see something when electrolysis was turned on (maybe 90%); and those in which the current density was less than 100 ma cm^{-2}, - most other investigations).

The first goal of future investigations will be to determine why the great time is needed; why various electrodes switch on sporadically, and why the phenomena occur in bursts.

Thus, when a competent investigator such as David Williams at Harwell says he does not observe any phenomena in his system ("but only a few bursts"), I find his statement consistent with the observations in my lab. The difference is one of attitude. For me, the important aspect is the anomalous behavior. A reproduction of the expected result is surely of lesser interest.

2) Scientists in general are wont to eschew the emotional factor of their work.

In fact, the most remarkable aspect of the discovery of electrochemical confinement is the great outburst of negative emotion which has flown from those concerned with rival (but unsuccessful) methods of obtaining confinement. In observing the shaking hand, the red face, the raised voice, the accusations of fraud, or gross stupidity, - I must say that I have never seen anything similar in my long career.

Under such circumstances, in this country, the fledgling phenomena, irreproducible and difficult to find, seem likely to be smothered in howls of rage still being emitted by those who are powerful and who control funding of the needed research.

If commercialization becomes scientifically feasible, it seems likely to occur in a nation where minds are less affected by the influence of the green-eyed Goddess. Thus, on August 1, the first of several Japanese Institutes began work - with 80 co-workers.

Yours sincerely,

J. O'M. Bockris
Distinguished Professor of Chemistry

JOMB/nr

P S I have mailed you 7 or 8 of my papers on separation factors.

ADDENDUM

LABORATORIES OBSERVING PRODUCTION OF TRITIUM DURING THE ELECTROLYSIS OF DEUTERIUM OXIDE AS OF SEPTEMBER 1989:

Packham, Wolf, Velev, Kainthla and Bockris, Texas A&M
Origin: Personal experience and paper

Grozzi, University of Rome
Origin: Personal communication at Santa Fe

Storms, Los Alamos
Origin: Personal visits, very detailed presentation

Ramirez, Institute for Petroleum Research, Mexico City
Origin: Detailed telephone presentation on numerical results to N.J. C. Packham; paper in Spanish being translated by Maria Gamboa.

Schoessow and Wethington, University of Florida, Gainesville
Origin: Detailed telephone presentation of results

Adzic, Case-Western University, Cleveland
Reports 7 x increase in T on telephone.

Iyengar, Bhabha Atomic Research Center
Origin: Paper at Karlsruhe

Landau
Origin: Personal communication and visit to laboratory

Furtak, University of Colorado, reported in Douglas Morrison's News Letter.

Oak Ridge
According to Kevin Wolfe, his August visit to Oak Ridge showed heat in chemistry and tritium in Fusion Physics Departments.

Should you find that any of these statements are not verified, I would be glad if you would let me know.

I note your statement that you must depend upon written statements and not upon rumors. However, it may be that at the present stage, where there is still a great deal of negative feeling among politically powerful fusion physicists, whose work on sustainment has hitherto been unsuccessful, verbal statements are all you may be able to get on the positive side.

Thus, a member of a National Laboratory approached me at a recent meeting and asked me for confidence as to his results. I asked him why I should not pass them on to my colleagues, and he replied with the following immortal words: "My boss would kill me if he knew I was telling you this. You see, they're positive." Correspondingly, a well known electrochemist from a Great Corporation's Lab called me to tell me of 48% excess heat. "I knew I had to get ride of that before my Boss found out".

HLF → JB 11/IX/89

PERSPECTIVES

Fleischman defends cold fusion

An unperturbed, unshaken Martin Fleischman tried to lay a few ghosts to rest at the IUPAC conference in Stockholm last month. Explaining why he and Stanley Pons had believed that there was a 'marginal' chance of inducing solid state fusion, he cited their theories that deuterons are shielded and exist as D^+ in the metal lattice, and further, that D^+ behaves as a classical oscillator, resulting in high compression and long confinement times in the lattice. Together these factors could lead to fusion (*Chem. Br.*, 1989, **25**, 564). 'We realised', he said, 'that there might be many reasons why this might not work, but we could see some reasons why it might work'.

Referring to the controversial experiments, Fleischman said that 'the excess heat generated was 10^9–10^{12} orders of magnitude above what we had expected from rudimentary measurements of radiation. And after the experiment had been running for hundreds of hours the excess enthalpy was 1–10 MJ cm^{-3} which is 10–1000 times what can be explained by chemistry.

'Moreover, while the energy of the cell is increasing the voltage across the cell is decreasing, implying that the energy input of the cell is decreasing—no way can this be explained by chemistry!'

Fleischman was adamant that he and Pons had done all the control experiments required. 'I think that it is an outrage that we should be accused of such sloppy experimentation', he said. 'Let me assure you that we are more critical of our work than others are'.

Pons and Fleischman are currently concentrating on the excess heat measurements, and have broadened their investigation to include other techniques. They use the cheap and cheerful method of heat transfer from a Dewar calorimeter under radiation control; flow calorimetry, which is an absolute technique and does not depend on calibration; and closed calorimetry in which no evolution of gas is allowed, making it a more difficult and potentially more dangerous method.

The latest results coming from the Utah camp indicate that the excess heat is in fact produced in bursts, usually after the experiment has been running for about two months. These bursts of heat can last from hours to days and are of the order of 4 MJ over a couple of days. 'Since we announced these "pulses" at the Electrochemical Society meeting in Los Angeles a couple of months ago (*Chem. Br.*, 1989, **25**, 691), several other people have come forward and said that they also have seen such pulses', Fleischman said. But he added that they were unlikely to publish these results because 'they just might be ridiculed as much as we have been'.

So why then have there been so many failed attempts to repeat the cold fusion experiments? Even scientists at Harwell, who ran their experiments continuously for periods of up to six weeks, did not come close to the claims of Pons and Fleischman (*Chem. Br.*, 1989, **25**, 769). 'There are some simple reasons for a lot of the failure', claimed Fleischman. 'From our work it seems clear that one has to use large electrodes at high current densities for very long periods, and if one is to detect tritium, neutrons or γ-rays we think that the electrode must be polarised for a very long time, and this is difficult'.

Fleischman went further and speculated. 'I think that what we have here is "threshold phenomena"—the main threshold being that it is necessary to reach a certain high current density in order to get the bursts of excess heat that we are observing. We have seen bursts only above 50 mA cm^{-2}. But clearly at about 500 mA cm^{-2} these bursts become more frequent. We are currently trying to develop "heroic electrochemistry"; we are trying to force the system to more extreme conditions to produce the bursts more regularly and continuously. Of course everything falls to pieces when you do that. Incidentally, we have had negative results, and we will of course continue to look for systematic errors to explain them'.

But as anyone will know if they have worked in calorimetry, it is difficult and somewhat unpredictable. Calorimetry on reacting chemical systems is even more difficult—there are many pitfalls and it usually takes several years to develop expertise in it. But as Fleischman said, 'it is important to make mistakes in science—if you only want to be right you will never discover anything'. ☐

Sticking with silicone

Putting an adhesive patch onto your skin seems like an easy way to take medication, but those with sensitive skins will know how easy it is for a sticky patch to become a form of torture. However, the wide range of materials now available means that those allergic rashes could become a thing of the past.

Transdermal drug delivery (TDD)—delivering a drug through the skin from one of these sticky patches—has come on in leaps and bounds in the 1980s. Examples of successful TDD include nitroglycerin patches for treating angina pectoris. There are several of these on the market, including Ciba-Geigy's Nitraderm TTS, Searle's Nitrodisc and Pharma-Schwarz/Lohmann's Deponit. A new area is progesterone or oestradiol contraceptive patches, such as Ciba-Geigy's Estraderm TTS. Potential also exists for delivering the anti-inflammatory NSAID indomethacin locally.

The general pattern of a patch is an impermeable backing layer, which protects the patch from the environment, a matrix or reservoir, which incorporates the drug itself, and an adhesive, which may itself contain the drug. This is covered by a release layer which is peeled off before sticking the patch on.

Skin compatible adhesives so far have included pressure sensitive adhesives (PSAs) based on polyisobutylene and polyacrylate; the newest generation includes silicones. Silicone PSAs were first introduced into medicine in the 1950s and quickly became popular because of their excellent biocompatibility and adhesion.

Silicone PSAs consist of a polymer plus a resin to provide 'tack'—the quick stick of initial application. Proper adhesion develops over a period of time (say *ca* 30 min) after application to the skin. Adhesion depends on the softening temperature of the adhesive—if it is less than the skin temperature (as in silicone PSAs) the adhesive will begin to flow into the folds and creases of the skin.

The low glass transition temperature, T_g, of medical grade silicones is also important because it allows the drug to permeate the adhesive to get to the skin. Low T_g silicones show greater conformational flux and rotation of substituents round the silcone Si–O backbone; high T_g materials are more 'frozen' and have lower permeability. Clearly this is a parameter that needs to be optimised for TDD.

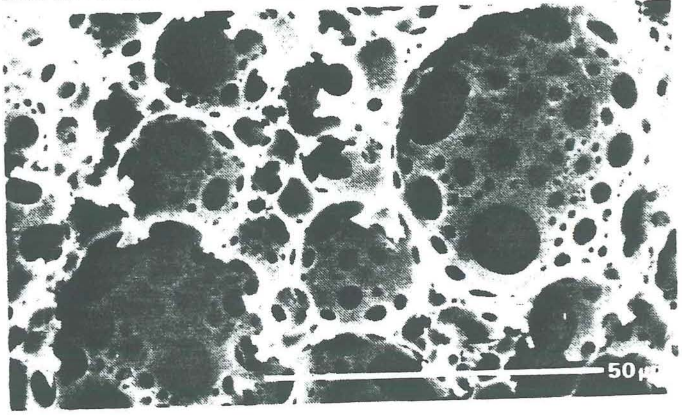
Medical grade silicone adhesives can also be manipulated by altering the proportions of polymer or resin in the adhesive. Generally they contain a low viscosity dimethylsiloxane polymer with a terminal silanol group (—OSiOH). The silicone resin has a three dimensional silicate structure with terminal trimethylsiloxy groups $(—OSi[CH_3]_3)$ and also silanol groups. The adhesive is produced from these component parts by dissolving in a hydrocarbon solvent such as Freon, naphtha or toluene, and in solution the silanol groups crosslink to form SiOSi siloxane bonds. This results in a higher weight polymer, the exact properties of which depend on the degree of crosslinking and the amounts of resin and polymer used. No stabilising additives are needed for silicone PSAs because they are stable over a wide temperature range.

More than 85 per cent of today's drugs contain an amino functionality and these groups can initiate crosslinking of silanols and potentially interfere with the PSA properties. The PSA Dow Corning 355, for example, contains a lot of silanol groups and can be so affected, but by trimethylsilylating the silanol groups the crosslinking is inhibited. A new silicone PSA from Dow Corning, BIO-PSA Q7-2920, has been treated in this way to be compatible with most amino-based drugs.

Silicone PSAs are fêted for their adhesive properties so one interesting problem was to find a release layer that did not stick too well to the patch before use! Fluoropolymer layers, with a low permeability and reactivity and low surface activity, have sorted out that one. ☐

Micropores have wide uses

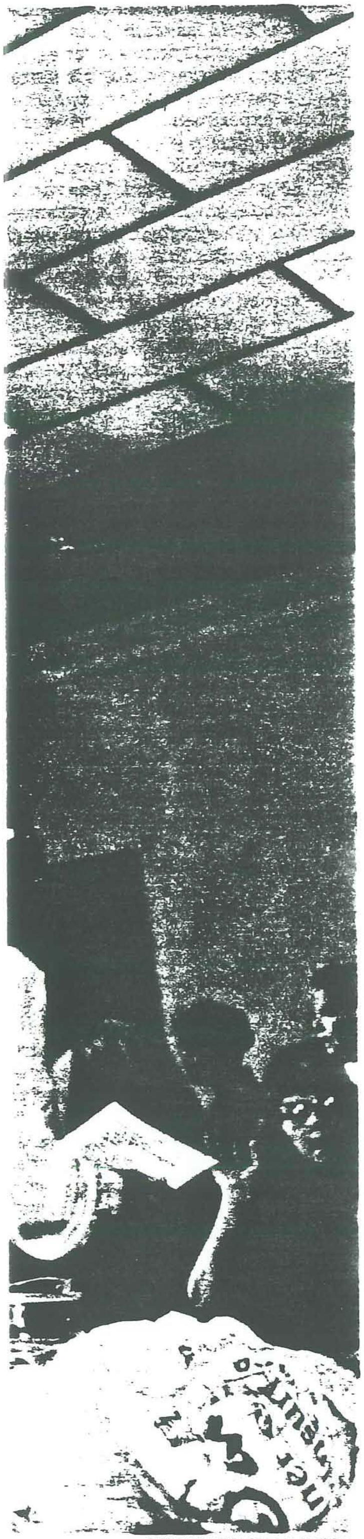
A new range of porous supports for peptide synthesis has been launched this summer by National Starch and Chemical, part of Unilever. The Polyhipe series of supports is based on a rigid porous polymer made by a new emulsion process. The cellular matrix of crosslinked polymer can be used directly or with gels chemically grafted into the structure. Two series have been launched initially: Polyhipe AM is a directly functionalised matrix without gel, while Polyhipe P has polyamide gel bound onto the structure. They can be used in large scale batch or flow peptide synthesis. National is developing a range of products based on this patented emulsion technology, for applications such as cell and enzyme immobilisation and biochemical separations.



SION

Out of Utah came the promise of the century: cheap, abundant, safe nuclear energy. But then came the hard questions.

By Robert P. Crease and N. P. Samios



DIANA WALKER/GAMMA-LIAISON

ON MARCH 23, DR. B. STANLEY Pons of the University of Utah and Dr. Martin Fleischmann of England's University of Southampton announced that, working together, they had created nuclear fusion at room temperature in a test tube.

Fusion, the process that powers the sun, ordinarily takes place at hundreds of millions of degrees. The announcement that so-called cold fusion had been achieved stunned the scientific community. We, like most of our colleagues, followed the story as it unfolded in the academic and popular press. With a mixture of excitement and skepticism, we learned that Pons and Fleischmann claimed to be generating four times as much energy as they were putting in, using a small device built with $100,000 out of their own pockets. Scaled up, the process could conceivably power cities. Small wonder that businessmen and politicians took notice, for such a device would revolutionize the creation and distribution of energy — and with it, the shape of international politics.

"Today we may be poised on the threshold of a new era," declared the chairman of the House Committee on Science, Space and Technology the following month, welcoming Pons and Fleischmann to a Congressional hearing devoted to their achievement. "If so, man will be unshackled from his dependence on finite energy resources."

Alas, by July, the new era had already stumbled and begun to fall on the threshold.

Today, with their findings almost universally discredited, Pons and Fleischmann continue to cling to their assertion that they have found something new. "We are absolutely sure of our results," Pons told The Wall Street Journal earlier this month. Earlier, Fleischmann had said, "If the amount of heat is so large you can't account for it by chemical reactions, then what else are you going to believe?"

In fact, there may be another factor at work — self-deception.

Pons and Fleischmann apparently fell victim to the experimental scientist's worst nightmare. Usually, self-deception is quickly and relatively painlessly cleared up, either through the scientist's own labors or those of a neighboring lab bench. What made the case of Pons and Fleischmann different was their meteoric and public rise to celebrity, and their equally spectacular and public downfall.

NUCLEAR ENERGY IS PRODUCED WHEN AN ATOMic nucleus is split, in the process called fission, but it is also produced when two light nuclei are squeezed into one heavier nucleus, a process known as *fusion*. Fusion, at least theoretically, has several advantages over fission as an energy source. It can be fueled by deuterium, which is easily extracted from ordinary seawater; a fusion reactor would produce less dangerous types of radioactive wastes and would be immune to meltdown. As troubles with fission-generated nuclear power mounted, the promise of fusion power beckoned.

But it was not to be easily achieved. Atomic nuclei are positively charged, and hence repel each other. Bringing two positively charged deuterons — deuterium nuclei made up of a proton and a neutron — close enough together for fusion to occur means overcoming an immense electrical repulsion called the Coulomb barrier. The conventional way of overcoming the barrier is to heat up a dense swarm of deuterons and other particles to several hundred million degrees. At those temperatures, the particles move very rapidly, resulting in collisions violent enough to overcome the Coulomb barrier. The scientific and engineering problems involved are enormous, however, and until last spring practical fusion energy seemed to be decades in the future.

Then came Pons and Fleischmann's sensational Salt Lake City press conference. They claimed, essentially, to have come up with a trick to overcome the barrier. Beginning with a mixture of lithium and heavy water (a form of water made with deuterium rather than ordinary hydrogen), they then inserted two electrodes, a negatively charged electrode made of palladium and a positively charged electrode made of platinum, and passed an electric current through the solution. In their experiment, Pons and Fleischmann found that the temperature of the water rose by an unexpected amount. Calculations showed a fourfold increase in energy output, they said, compared to what they were putting in.

What was causing the increase? Pons and Fleischmann offer the following explanation: As expected, the electric current causes the water molecules to break up and the positively charged deuterons to migrate to the negatively

Robert P. Crease is an assistant professor of philosophy at the State University of New York at Stony Brook and historian at Brookhaven National Laboratory. N. P. Samios is director of the Brookhaven National Laboratory.

Victims of self-deception? Martin Fleischmann, left, and Stanley Pons told Congress they had achieved fusion at room temperature. Below: Turn-of-the-century scientist René Blondlot thought he saw N-rays.

KORB/ARCHIVES DE L'ACADEMIE DES SCIENCES, PARIS

THE BETTMANN ARCHIVE

Wilhelm Roentgen discovered the X-ray by accident, and kept his observations to himself until studies backed him up.

Eureka! It can happen. But in science, the miraculous must be regarded with extreme skepticism.

charged cathode, the one made of palladium. Palladium, like other metals, is a crystal, meaning that its atoms are arranged in a regular, tessellated pattern. Its particular atomic structure allows it to absorb deuterons like a sponge. The deuterons lodge themselves in the interstices between the atoms, eventually crowding in two to a space. Powerful electromagnetic forces produced by the palladium atoms squeeze the deuterons together. This pressure, Pons and Fleischmann postulate, pushes the deuterons past the Coulomb barrier and causes them to fuse, with the concomitant release of energy in the form of heat.

Pons and Fleischmann's "trick" was to fuse nuclei not through violent collisions but by compressing them in the miniature vise created by the palladium atoms. No need to create a sun in the laboratory, no need for the equivalent of a hydrogen bomb. Just a tub of heavy water, an electrolyte, two electrodes and some current.

Equally surprising was the relative lack of neutrons produced. Neutrons are a radioactive byproduct of all known fusion (and fission) reactions — and their presence in nuclear reactors is a major factor in making them hazardous places to be. They also contaminate structural elements of the reactor, creating waste-disposal problems. If the excess heat that Pons and Fleischmann reported was due to fusion, then they should have found a neutron flux of 10^{13} neutrons per second in their laboratory — comparable to the amount produced in nuclear reactors. But they reported only 10^4. They attributed this to the fact that a new form of reaction was taking place. Wonderful! No need for tons of lead shielding, no vexing problem of waste disposal, no need to decommission plants because their parts had become too hot to handle.

At first, excitement mounted as teams of experimenters at the Georgia Institute of Technology, Texas A & M, Stanford University and elsewhere reported apparent confirmations of aspects of the Utah results. Pons, Fleischmann, the University and State of Utah submitted joint patent applications; dozens of corporations contracted to take a look. Palladium futures soared.

Peter Hagelstein, of the Massachusetts Institute of Technology, produced a theory to account for the Pons-Fleischmann observations, and submitted four papers on it to a scientific journal. Utah's Senator Jake Garn proudly chartered a plane for Senate colleagues to fly to Salt Lake City to witness the miracle first-hand. The Utah Legislature offered $5 million to Pons and Fleischmann for follow-up studies. And the two went to Washington to seek $25 million for seed money to start a $100 million Center for Cold Fusion Research.

But it wasn't long before some laboratories reported difficulty duplicating the observations; Georgia Tech withdrew its confirmation. Pons and Fleischmann offered little help to the unfortunates struggling to repeat their work; they declined to provide details of their techniques, refused to send samples of their equipment to laboratories for analysis, and withdrew the paper they had submitted to the scientific journal Nature, claiming that they preferred to press on with more urgent work rather than stop to handle the reviewers' criticisms. Hagelstein's papers remained unpublished; Garn cancelled the charter flight. One by one, laboratories dropped out of the cold-fusion quest, and corporations stopped knocking on Utah's door. In mid-July, a scientific advisory panel to the Department of Energy recommended that the agency not support the work of Pons and Fleischmann. "Evidence for the discovery of a new nuclear process termed cold fusion is not persuasive," the panel concluded. (The D.O.E.'s final report is due in November.)

Scientists began to dub any spurious result a "Utah effect." Wags began peddling "cold-fusion kits," each consisting of a test tube, a pair of electrodes and an Alka-Seltzer tablet, for $4.95 — "regular price $5M."

THERE WERE SCIENTISTS WHO HAD SEEN AS EARly as the original press conference that something was amiss, and many more knew after a glance at a pirated copy of the Nature article, which was faxed and refaxed around the world. What tipped them off was the presence of certain tell-tale signs, sometimes known as "symptoms of pathological science." Cold fusion may someday rank among such notorious scientific nondiscoveries as the Martian canals, N-rays and polywater. But it is more than a classic example of pathological science; it also provides a lesson about how experimental science works and why it is enormously difficult.

Self-deception in science is very different from fraud. Few working scientists lose sleep over fraud. The reason is simple: The motive for fraud is almost always résumé-padding — adding lines to a bibliography by publishing fabricated or plagiarized work. But this succeeds only when the work is trivial, insignificant or peripheral; if at all noteworthy, it will be exposed when other researchers try to duplicate and explore it. As Daniel Koshland Jr., editor of the journal Science, put it, "The bigger the result, the more quickly it is going to be checked." A successful fraud may contribute to the culprit's career but it rarely alters the course of science.

Self-deception, however — involuntarily or unconsciously being led astray — is a daily threat to every experimental scientist. Nonscientists often write of researchers as if all they need do is switch on their equipment and — presto! — *facts* appear, as if the real work of science consists of fitting such facts into theories.

But experimental science is far more complicated — and more interesting — than that. When an experiment begins producing results, the experimenters must still make sure that the readings represent a true profile of a scientific phenomenon — that the data have not been produced by something else in the environment or idiosyncracies of the equipment. To guard against these "systematic effects," as they are called, scientists run experiments over and over, making small changes in the equipment to see whether the effects change. Experimenters typically are suspicious of early data runs, and habitually ask themselves such questions as "How *good* are these data?" and "What *else* could they be due to?"

Impure materials, for instance, have ruined experiments. A classic example is the case of a reputable 19th-century chemist named Chenevix. Studying, as it happened, the recently discovered element palladium, Chenevix became convinced that it was not an element at all but a compound of other substances. He circulated his findings among his peers and the general public, ridiculed those scientists who declared it to be an element — and was subsequently horrified to discover that he had erred, apparently by using chemicals that already contained the palladium he believed he was producing from scratch. Utterly humiliated, he abruptly quit science.

Even when the materials are pure, the equipment performs well and is used skillfully, the results must still be "read" correctly.

In the 1930's, a prominent physicist named Irving Langmuir coined the term pathological science, or what he called "the science of things that aren't so." Pathological science, he said, has a characteristic set of symptoms, and he drew up an informal list based on his own experiences. We have drawn up our own, based on ours. It is, we realize, neither exhaustive nor infallible. Genuine science might display any one of these symptoms; pathological science is usually accompanied by several.

Symptom No. 1: Too many miracles.

Miracles do occur in science. On Nov. 8, 1895, the German scientist Wilhelm Roentgen noticed that a fluorescent screen on the table of his laboratory was glowing. Fluorescent crystals glow in the presence of light, but Roentgen had darkened the laboratory, in order better to examine emissions produced by the cathode ray tube he was using. He switched off the instrument and noticed that the glow stopped immediately. Astonished, and not quite trusting his eyes, he embarked on a systematic study of the phenomenon — fluorescence in the absence of light — without mentioning anything to anyone. Finally, on Jan. 1, 1896, he sent a paper to colleagues announcing the discovery of invisible "X-rays," emitted by the cathode ray tube, which were able to pass through paper, wood and even the human body.

Many scoffed; one scientist called the story of the rays a "fairy tale." Every well-stocked laboratory had cathode ray tubes and fluorescent screens, and it seemed highly unlikely that such an effect had not been noticed before. (In fact it had been, but the observations were disregarded.)

Five days later — after scientists had had a chance to read Roentgen's paper — the story of X-rays was splashed across the front page of several newspapers. Within three weeks of the discovery, physicians in Dartmouth, N.H., used them to help them set the fractured arm of a boy named Eddie McCarthy. Roentgen had no "theory" of what the mysterious rays were, hence their name. But when the Nobel Prizes were established in 1901, the first physics award went to him.

Seven years after Roentgen's discovery, a distinguished French scientist, René Blondlot, announced the discovery of "N-rays," which like X-rays were able to pass through paper, wood and sheets of iron, silver and gold. Like Roentgen, he mailed an account of the sensational news to leading scientists all over Europe. N-rays were even more miraculous than X-rays, able to traverse materials in ways that violated known electromagnetic laws. And they were also emitted in some mysterious and unexplained way by living tissue, especially nerves and muscles.

Many scientists were disturbed by how much existing scientific knowledge had to be suspended in order to swallow the discovery, and were not surprised when laboratories in Germany and Britain had difficulty reproducing N-rays, or when some laboratories retracted their early confirmations. The rays were exposed as false most dramatically when an American physics professor visiting the lab se-

Reader's Digest moves people to become an active force for positive change in their communities across America and around the world.

Each month, we serve our readers by providing vital, contemporary information to help them better their lives. Even with differences in language and local content, all 39 editions of *Reader's Digest* share this goal. That's why we're the world's most widely read magazine.

Our involved readership of over 100 million worldwide has responded to articles on the dangers of drug abuse and AIDS, ways to improve education and promote sober driving. We do more than report problems – we offer sources of helpful information and suggestions for solutions.

And our magazine is only part of what we do.

Reader's Digest. We're a leading force in providing knowledge and entertainment to the world through magazine and book publishing, music and video products, travel a financial services. We also provide significant support for programs for youth, education, the arts and humanities, both directly and through Reader's Digest Foundati

Reader's Diges

We make a differenc in 100 million lives worldwid

People movers.

Reader's Digest
THE PLAGUE THAT KNOWS NO BOUNDARIES
THE BUGGING OF OUR MOSCOW EMBASSY
"I TOUCH THE FUTURE..."
Det Beste fra Reader's Digest
Sélection Reader's Digest

cretly pocketed a supposedly crucial piece of the apparatus while Blondlot and his assistant continued their observations unperturbed. Blondlot had clearly fallen victim to a grand case of self-deception. The numerous miracles his finding required were an early sign.

Cold fusion, too, required too many miracles. The first was that an utterly unknown way of achieving fusion had escaped the attention of generations of nuclear physicists. The second was that deuterons could be squeezed closely enough together inside palladium for fusion to occur. The third was that the fusion produced so few neutrons. Each miracle, taken separately, was plausible. But the simultaneous appearance of three was strong circumstantial evidence of pathology at work.

Symptom No. 2: The "discoverers" are outsiders.

In the early 1970's, an astrophysicist named Ian McCusker decided to step into particle physics in search of single quarks — fundamental particles with electric charges a fraction of those of the electron and proton. Particle physicists were fairly sure that they came only in trios or in pairs (consisting of a quark and an antiquark) with a total integral charge. Single, isolated quarks had been hunted for years without success. McCusker decided to look anyway — and promptly announced, at a conference in Hungary in 1974, that he had found them.

Again, most scientists first learned of the discovery through the newspapers, and eagerly awaited details. McCusker visited several laboratories, armed with cloud-chamber photographs of particles whose tracks were sparser than usual, and asserted that such tracks could only be produced by a particle with a fractional charge.

At Brookhaven National Laboratory, particle physicists asked him whether he had measured the density of each of the tracks in his pictures, whether made by a quark or other particle. He hadn't felt it necessary, he said. When further experiments, replicating McCusker's work, looked at all the tracks, including those of the kind McCusker had ignored, scientists could see that the "quark" tracks had been produced by normal particles and that their sparseness was the result of systematic effects.

McCusker's phantom quarks are but one instance of outsiders making discoveries that turn out to be false. Outsiders start with the disadvantage of hostility from insiders — which they invariably interpret as, at best, the inertial resistance of a hidebound community to bright new ideas, and at worst as xenophobia. But a general skepticism about outsiders is still well-founded. An insider knows the traps, has made the mistakes, and is aware of the temptations. Discoveries are usually made when a person intimately familiar with the field learns or does something and the implications suddenly snap into place. They do happen when someone playing around in unfamiliar terrain stumbles across something that the locals have overlooked — but this is very rare.

Outsiders, however, have the advantage of appearing to the public as Davids in a contest against Goliaths. Pons and Fleischmann, both chemists equipped with the equivalent of slingshots, strode into the province of nuclear physicists, who inhabited huge laboratories well-funded by the Federal government. Add to that romantic image one final touch: the well-known chauvinism physicists tend to have about their field. Small wonder the press cheered, and that editorials in prominent newspapers scorned the "compulsive naysaying" of the establishment's "academic mentality" that dared to question their feat.

As newcomers, Pons and Fleischmann seem to have fallen into several traps that experienced physicists might have avoided. For example, old hands know that where you place the thermometer in a mixture can affect temperature readings. Some physicists have claimed the mixture Pons and Fleischmann worked with should have been stirred to get a uniform temperature; it's unclear whether Pons and Fleischmann did that. Then too, physicists say, Pons and Fleischmann may have encountered difficulties in counting neutrons and gamma rays.

In the long run, scientists paid far more attention to the work of Steven E. Jones, a physicist at Brigham Young University, who at the same time as Pons and Fleischmann's announcement had made a much more modest claim about cold fusion. Jones claims that he detected fusion, but at a level that, as he said, bore the same relation to Pons and Fleischmann's measurements as a dollar bill to the national debt. His colleagues took him seriously not because he was one of their own, nor even because he showed up at all the important meetings to defend his work. Rather, it was because his work betrayed an awareness of potential pitfalls. When Jones reported detecting cold fusion, though at rates far too low to be commercially practical, it was counted as a genuine scientific claim — and still is.

> A scientific paper is like a recipe. If others can't produce the dish, the chef is probably wrong.

Symptom No. 3: The discoverer has not tried to kill the discovery.

The microbiologist Ludwik Fleck, in "Genesis and Development of a Scientific Fact," a landmark book on the practice of science, compared scientists like Roentgen to Columbus; they set out for an "India" and suddenly run into "America." Inevitably, the discoverer initially is bewildered by the appearance of the unexpected. But most scientists are not as fortunate as Roentgen, and the unexpected turns out not to be a new continent but something produced by faulty or misread equipment. Therefore, the first instinct of a good experimenter, when confronted with the unexpected, is to try to "kill" it — to track down every possible conventional explanation. Anyone prepared to announce the discovery of a new continent should be certain it's not familiar territory misidentified.

A true scientific phenomenon is invariant; it will show up in many different kinds of equipment in different circumstances, somewhat the way a real object can be seen by many different people and from many different angles. Often, an object can momentarily appear to be something it's not — the way, for instance, a photograph might seem to show George Bush with a tourist on a Washington street corner, whereas in reality "Bush" is a cardboard prop. In trying to kill an unexpected result, scientists vary the systematics of the experiment, and make sure to collect plenty of statistics.

Pons and Fleischmann were unable to convince their colleagues that they had made a genuine attempt to kill their results. To all appearances, they had not varied those parameters that one ordinarily varies for studying systematic effects. They hadn't performed the experiment, for instance, with ordinary water instead of heavy water. Nor had they adequately checked the reliability of the neutron detectors. Georgia Tech withdrew its confirmation when it discovered, through systematic checks, that its neutron counters were temperature sensitive.

To be sure, the history of science does contain cases of "overkill," in which good scientists have ignored new phenomena staring them in the face. Leon Lederman, former director of Fermilab and winner of the 1988 Nobel Prize in physics, once wrote a paper about "the big ones that got away." In attempting to kill unexpected results by pushing conventional explanations as far as possible, he explained away real breakthroughs, including several that later won their discoverers Nobel prizes. Still, he is in fine company; fellow Nobel laureate Irène Joliot-Curie, to name but one, realized — after a rival discovered it — that she had observed nuclear fission. But she had convinced herself that the phenomenon could be ascribed to things she already knew.

Symptom No. 4: Inability to repeat the experiment is met by ad hoc excuses.

An experimental scientific paper is in some sense a recipe. It does two things. First, it testifies that the experimenters have a result they want others to know about; second, it provides directions for others to follow. It need not describe every detail — where the bowls were bought, the brand names of the ingredients — but assuming a background set of concepts and a standardized set of laboratory practices, a scientific paper warns, "*This* is the tricky part. Watch out for *that.*" Scientists establish credibility and priority for discoveries by laying out their work as openly as possible. A scientific paper with an inadequate recipe is a tip-off that the authors' understanding of their work is incomplete.

Blondlot, for instance, was never able to provide a sufficient recipe for N-rays. When his colleagues said that they couldn't detect the rays, Blondlot produced additional details, accompanied by dark suggestions that those couldn't repeat his work incompetent. A few of B lot's champions even b claiming that only indi als of Latin descent had enough eyesight to see dence of the rays.

Pons and Fleischman lowed this pattern. someone claimed that it not possible to produce fusion, the two Utah s tists would add more ins tions — that the palla cathode had to be prepar a certain way, or the ele lyte had to be of a certain centration. As Robert head of the Washington o of the American Phy Society, remarked, time someone did the ex ment with no result, would say, 'You didn't d experiment right,' and up another tidbit."

WHY DOES PA ological sci occur? The vation may be a desir fame, immortality, weal or a genuine desire to mankind. Fleischmann stated that the motiv for the Utah team's was social: "We reco the desperate energy n that will confront the century," he said. But if desires interfere with disinterested evaluation testing, the outcome ma pathological science.

If Pons and Fleischman tually achieved what claimed, to get the scie community to change its about cold fusion they have to start over scratch — by publishing i scientific literature, de strating expertise in the p dures, showing that they tried and failed to kill thei sults, and providing a com hensive set of instructions others can follow.

In the movie "Back t Future" the time-trav DeLorean is powered small device that runs beer. The label reads:

Mr. Fusion
Home Energy Reactor

The scene effectively tures, and sends up, the science seems to be stantly discovering, sim ing, standardizing and m turizing complex and po ful phenomena in such a that they can be handle ordinary people with scientific training at all. world may someday co fusion devices that will convenient as automatic fee makers. But if so, t will be no shortcuts in scientific process lea from here to there. ■

Dallo Utah: scusateci, la fusione fredda è un sogno

09/29/89

REPLAY

IL GIOCO CHE TI RIMETTE IN GIOCO.

Oggi Replay duplica

In palio 20 milioni

Correte a pagina 5

SALT LAKE CITY — Un'altra doccia gelata sulla fusione fredda. Anche all'università dello Utah, dove gli scienziati Pons e Fleischmann diedero il grande annuncio nel marzo scorso, sono costretti ad ammettere che tutti i tentativi fatti finora per riprodurre la fusione nucleare a freddo sono falliti.

Non è escluso che presto dovrà chiudere i battenti il neonato Istituto nazionale della fusione fredda, inaugurato grazie ai sei miliardi di fondi forniti prontamente dal governo.

Nessuna delle «pile» elettrochimiche (più di venti) predisposte dall'Istituto per duplicare l'esperimento che i due chimici affermarono di avere eseguito più volte in barattoli di vetro a temperatura ambiente ha dato energia maggiore di quella immessa o prodotti tipici della fusione nucleare. Pons e Fleischmann, in questi giorni, sono in Giappone per alcune conferenze.

A pagina 7

OGGI

CORRIERECONOMIA

Cresci America cresci
Un'inchiesta sulla Bushnomics

*

La lira? E' forte
Sondaggio fra i banchieri internazionali

*

Lobbisti
Sirene italiane a Washington

*

Ventriglia
'O professore e il suo segreto

*

Moda
I giapponesi a caccia di griffe italiane

*

Immobili
De Benedetti conquista piazza Scala

*

Perestrojka padana
Il sogno bolognese

Oggi con il Corriere

La seconda guerra mondiale

raccontata da **ENZO BIAGI**

Nel secondo fascicolo: I tedeschi a Parigi - Olanda e Belgio a ferro e fuoco - In Norvegia la guerra tra i fiordi - Dunkerque: la vittoriosa sconfitta - Compiègne: il vagone della vendetta.

Sono falliti tutti i tentativi di riprodurre il controverso esperimento di Pons e Fleischmann

09/29/89

Dagli USA doccia gelata sulla fusione fredda

SALT LAKE CITY — Un'altra doccia gelata sulla fusione fredda. Anche all'università dell'Utah, dove gli scienziati Pons e Fleischmann diedero il grande annuncio a marzo, sono costretti ad ammettere che tutti i tentativi fatti finora per riprodurre la fusione fredda sono falliti e non si esclude di dover presto chiudere i battenti del neonato Istituto nazionale della fusione fredda, inaugurato grazie ai sei miliardi di fondi forniti prontamente dal governo.

⧉

Nessuna delle «pile» elettrochimiche (più di venti) predisposte dall'Istituto per duplicare l'esperimento che i due chimici affermarono di avere eseguito più volte in barattoli di vetro a temperatura ambiente ha dato energia maggiore di quella immessa o prodotti tipici della fusione nucleare, cioé neutroni e trizio.

«E' arrivato il momento di incominciare a chiederci se facciamo qualcosa di sbagliato», ha dichiarato Huro Rossi, direttore dell'Istituto. E' una situazione «snervante», ha detto.

Pons e Fleischmann si trovano attualmente in Giappone e il loro ritorno non è previsto prima di giovedì, per cui non si conosce ancora la loro reazione. Le dichiarazioni fatte da Rossi danno ragione allo scetticismo con il quale il mondo scientifico internazionale accolse l'annuncio dei due chimici, che il 23 marzo prospettarono la possibilità di avere a portata di mano una fonte inesauribile di energia pulita e a buon mercato.

Secondo Pons, preside della facoltà di chimica dell'università dell'Utah, e Fleischmann, inglese, dell'università di Southampton, con il loro metodo sarebbe possibile con un secchio d'acqua di mare ottenere energia pari a quella fornita da una tonnellata di carbone.

I due sostennero che con un processo elettrochimico attuato dentro un vaso di vetro grande come un barattolo da cucina era possibile spingere due deuteroni (particelle nucleari di deuterio o idrogeno pesante, che abbonda nell'acqua di mare) attraverso un reticolo formato da elettrodi di palladio e platino, ottenendo la fusione di particelle con carica positiva e creando così nuovi atomi.

«Le indicazioni che abbiamo tratto dalle nostre ricerche ci dicono che la scoperta verrà con relativa facilità trasformata in una tecnologia utilizzabile per generare calore e energia», disse all'epoca Pons. Nonostante le critiche subito piovute da tutto il mondo su i due chimici, l'università dell'Utah brevettò l'esperimento Pons-Fleischmann e il governo dello Stato trovò senza indugi 4,3 milioni di dollari per creare «The national cold fusion institute».

⧉

Le dichiarazioni di Rossi sono giunte dopo la visita compiuta all'università la settimana scorsa da un esperto del Cern, il laboratorio europeo per la ricerca nucleare con sede a Ginevra. Si tratta di Douglas Morrison, che ebbe una serie di incontri con gli scienziati di Salt Lake City e dichiarò poi che i tentativi eseguiti in tutto il mondo per duplicare la «fusione fredda» lasciano ben poche speranze che sia fattibile.

```
Received: from Csa2.LBL.Gov by IBM.COM (IBM VM SMTP R1.2.1MX) with TCP; Wed, 27 Sep 89
19:49:05 PDT
Date:     Wed, 27 Sep 89 19:48:06 PDT
From:     hoffman@Csa2.LBL.Gov (Darleane Hoffman)
Message-Id: <890927194806.21c0238d@Csa2.LBL.Gov>
Subject:  Re: Slightly revised first draft
In-Reply-To: Your message <890924193329.20800170@Csa2.LBL.Gov> dated 24-Sep-1989
To:       schiffer%anlphy.bitnet@Csa2.LBL.Gov
cc:       jbigelei%sbccmail.bitnet@Csa2.LBL.Gov, rlg2@ibm.com,
         koonin%caltech@Csa2.LBL.Gov, hoffman@Csa2.LBL.Gov
```

Dear John,

I have received your slightly revised draft. I would prefer to amend my section on protons as per the FAX I sent you. I will send that via electronic mail so it will be easier for you to incorporate in the draft. Did you get my message concerning the correction of Porter et al.? Please confirm. Also I have checked with Buford Price and his paper has been submitted to Nature and we can distribute it as widely as we wish so I will FAX a copy to each of our working group members.

Best regards,
Darleane

Date: Wed, 27 Sep 89 14:49 EDT
From: JBIGELEISEN@SBCCMAIL.BITNET
Subject: NSF - EPRI Workshop on Cold Fusion
To: RLG2@YKTVMV.BITNET
X-VMS-To: in%"RLG2@YKTVMV.BITNET"

State University of New York at Stony Brook
Stony Brook, NY 11794-3400

Jacob Bigeleisen
Professor
Chemistry
516-632-7905
27-Sep-1989 02:33pm EDT

FROM:	JBIGELEISEN	
TO:	Remote Addressee	(_HUIZENGA@UORCHEM.BITNET)
CC:	Remote Addressee	(_RLG2@YKTVMV.BITNET)
CC:	Remote Addressee	(_KOONIN@CALTECH.BITNET)
CC:	Remote Addressee	(_HOFFMAN@LBL.GOV)
CC:	Remote Addressee	(_SCHIFFER@ANLPHY.BITNET)

SUBJECT: NSF - EPRI Workshop on Cold Fusion

John,

I was at BNL this morning and saw Peter Bond, Chairman of Physics and BNL coordinator for "cold fusion". He told me that NSF and EPRI were jointly sponsoring a workshop on cold fusion sometime in October. I believe it may be about the time of our Chicago meeting. Apparently the only people being invited are those who sho "positive" results. I believe that DOE should take this matter up with NSF. As a minimum, we should send Dave Goodwin and some additional DOE staff personnel as observers - you know the Freedom of Information Act. I took the opportunity to tell Peter Bond that I was going to recommend to DOE that he have his budget cut. During the last month the BNL cold fusion people have had the following outside speakers that I know of:

1. Srinivasan - Texas A&M
2. Huggins - Stanford
3. Jones - BYU
4. Inyengar of BARC is coming on 9 October.

Inyengar's visit is the first one I have heard about before the fact. I will not go to it. I will be in the Adirondacks (much better use of time).

Through the efforts and interests of Maurice Goldhaber and Joe Weneser I gave a seminar talk at BNL on the findings of our panel in mid August. There are some funny things goind on at BNL with respect to their cold fusion effort, if that is what one can call what they are doing. JAKE

09/29/89

Dallo Utah: scusateci, la fusione fredda è un sogno

oppo
o che
legge,
alisti,
taliz-

i pre-
e sedi
opi-
fare
liere
orio,
bi-
es-

REPLAY

IL GIOCO CHE TI RIMETTE IN GIOCO.

Oggi Replay duplica

In palio 20 milioni

Correte a pagina 5

SALT LAKE CITY — Un'altra doccia gelata sulla fusione fredda. Anche all'università dello Utah, dove gli scienziati Pons e Fleischmann diedero il grande annuncio nel marzo scorso, sono costretti ad ammettere che tutti i tentativi fatti finora per riprodurre la fusione nucleare a freddo sono falliti.

Non è escluso che presto dovrà chiudere i battenti il neonato Istituto nazionale della fusione fredda, inaugurato grazie ai sei miliardi di fondi forniti prontamente dal governo.

Nessuna delle «pile» elettrochimiche (più di venti) predisposte dall'Istituto per duplicare l'esperimento che i due chimici affermarono di avere eseguito più volte in barattoli di vetro a temperatura ambiente ha dato energia maggiore di quella immessa o prodotti tipici della fusione nucleare. Pons e Fleischmann, in questi giorni, sono in Giappone per alcune conferenze.

A pagina 7

OGGI

CORRIERECONOMIA

Cresci America cresci
Un'inchiesta sulla Bushnomics

*

La lira? E' forte
Sondaggio fra i banchieri internazionali

*

Lobbisti
Sirene italiane a Washington

*

Ventriglia
'O professore e il suo segreto

*

Moda
I giapponesi a caccia di griffe italiane

*

Immobili
De Benedetti conquista piazza Scala

*

Perestrojka padana
Il sogno bolognese

Oggi con il Corriere

La seconda guerra mondiale

raccontata da **ENZO BIAGI**

Nel secondo fascicolo: I tedeschi a Parigi - Olanda e Belgio a ferro e fuoco - In Norvegia la guerra tra i fiordi - Dunkerque: la vittoriosa sconfitta - Compiègne: il vagone della vendetta.

---

cialista».

con una lievissima

09/29/89

Sono falliti tutti i tentativi di riprodurre il controverso esperimento di Pons e Fleischmann

Dagli USA doccia gelata sulla fusione fredda

SALT LAKE CITY — Un'altra doccia gelata sulla fusione fredda. Anche all'università dell'Utah, dove gli scienziati Pons e Fleischmann diedero il grande annuncio a marzo, sono costretti ad ammettere che tutti i tentativi fatti finora per riprodurre la fusione fredda sono falliti e non si esclude di dover presto chiudere i battenti del neonato Istituto nazionale della fusione fredda, inaugurato grazie ai sei miliardi di fondi forniti prontamente dal governo.

⧉

Nessuna delle «pile» elettrochimiche (più di venti) predisposte dall'Istituto per duplicare l'esperimento che i due chimici affermarono di avere eseguito più volte in barattoli di vetro a temperatura ambiente ha dato energia maggiore di quella immessa o prodotti tipici della fusione nucleare, cioé neutroni e trizio.

«E' arrivato il momento di incominciare a chiederci se facciamo qualcosa di sbagliato», ha dichiarato Huro Rossi, direttore dell'Istituto. E' una situazione «snervante», ha detto.

Pons e Fleischmann si trovano attualmente in Giappone e il loro ritorno non è previsto prima di giovedì, per cui non si conosce ancora la loro reazione. Le dichiarazioni fatte da Rossi danno ragione allo scetticismo con il quale il mondo scientifico internazionale accolse l'annuncio dei due chimici, che il 23 marzo prospettarono la possibilità di avere a portata di mano una fonte inesauribile di energia pulita e a buon mercato.

Secondo Pons, preside della facoltà di chimica dell'università dell'Utah, e Fleischmann, inglese, dell'università di Southampton, con il loro metodo sarebbe possibile con un secchio d'acqua di mare ottenere energia pari a quella fornita da una tonnellata di carbone.

I due sostennero che con un processo elettrochimico attuato dentro un vaso di vetro grande come un barattolo da cucina era possibile spingere due deuteroni (particelle nucleari di deuterio o idrogeno pesante, che abbonda nell'acqua di mare) attraverso un reticolo formato da elettrodi di palladio e platino, ottenendo la fusione di particelle con carica positiva e creando così nuovi atomi.

«Le indicazioni che abbiamo tratto dalle nostre ricerche ci dicono che la scoperta verrà con relativa facilità trasformata in una tecnologia utilizzabile per generare calore e energia», disse all'epoca Pons. Nonostante le critiche subito piovute da tutto il mondo su i due chimici, l'università dell'Utah brevettò l'esperimento Pons-Fleischmann e il governo dello Stato trovò senza indugi 4,3 milioni di dollari per creare «The national cold fusion institute».

⧉

Le dichiarazioni di Rossi sono giunte dopo la visita compiuta all'università la settimana scorsa da un esperto del Cern, il laboratorio europeo per la ricerca nucleare con sede a Ginevra. Si tratta di Douglas Morrison, che ebbe una serie di incontri con gli scienziati di Salt Lake City e dichiarò poi che i tentativi eseguiti in tutto il mondo per duplicare la «fusione fredda» lasciano ben poche speranze che sia fattibile.

oppo
o che
legge,
alisti,
taliz-

i pre-
e sedi
opi-
fare
liere
orio,
bi-
es-

pe-
n-
si

09/29/89

Dallo Utah: scusateci, la fusione fredda è un sogno

SALT LAKE CITY — Un'altra doccia gelata sulla fusione fredda. Anche all'università dello Utah, dove gli scienziati Pons e Fleischmann diedero il grande annuncio nel marzo scorso, sono costretti ad ammettere che tutti i tentativi fatti finora per riprodurre la fusione nucleare a freddo sono falliti.

Non è escluso che presto dovrà chiudere i battenti il neonato Istituto nazionale della fusione fredda, inaugurato grazie ai sei miliardi di fondi forniti prontamente dal governo.

Nessuna delle «pile» elettrochimiche (più di venti) predisposte dall'Istituto per duplicare l'esperimento che i due chimici affermarono di avere eseguito più volte in barattoli di vetro a temperatura ambiente ha dato energia maggiore di quella immessa o prodotti tipici della fusione nucleare. Pons e Fleischmann, in questi giorni, sono in Giappone per alcune conferenze.

A pagina 7

REPLAY

IL GIOCO CHE TI RIMETTE IN GIOCO.

Oggi Replay duplica

In palio 20 milioni

Correte a pagina 5

OGGI

CORRIERECONOMIA

Cresci America cresci
Un'inchiesta sulla Bushnomics

*

La lira? E' forte
Sondaggio fra i banchieri internazionali

*

Lobbisti
Sirene italiane a Washington

*

Ventriglia
'O professore e il suo segreto

*

Moda
I giapponesi a caccia di griffe italiane

*

Immobili
De Benedetti conquista piazza Scala

*

Perestrojka padana
Il sogno bolognese

Oggi con il Corriere

La seconda guerra mondiale

raccontata da **ENZO BIAGI**

Nel secondo fascicolo: I tedeschi a Parigi - Olanda e Belgio a ferro e fuoco - In Norvegia la guerra tra i fiordi - Dunkerque: la vittoriosa sconfitta - Compiègne: il vagone della vendetta.

---

cialista».

posta è stata con una lievissima

Sono falliti tutti i tentativi di riprodurre il controverso esperimento di Pons e Fleischmann

09/29/89

Dagli USA doccia gelata sulla fusione fredda

SALT LAKE CITY — Un'altra doccia gelata sulla fusione fredda. Anche all'università dell'Utah, dove gli scienziati Pons e Fleischmann diedero il grande annuncio a marzo, sono costretti ad ammettere che tutti i tentativi fatti finora per riprodurre la fusione fredda sono falliti e non si esclude di dover presto chiudere i battenti del neonato Istituto nazionale della fusione fredda, inaugurato grazie ai sei miliardi di fondi forniti prontamente dal governo.

⁂

Nessuna delle «pile» elettrochimiche (più di venti) predisposte dall'Istituto per duplicare l'esperimento che i due chimici affermarono di avere eseguito più volte in barattoli di vetro a temperatura ambiente ha dato energia maggiore di quella immessa o prodotti tipici della fusione nucleare, cioé neutroni e trizio.

«E' arrivato il momento di incominciare a chiederci se facciamo qualcosa di sbagliato», ha dichiarato Huro Rossi, direttore dell'Istituto. E' una situazione «snervante», ha detto.

Pons e Fleischmann si trovano attualmente in Giappone e il loro ritorno non è previsto prima di giovedì, per cui non si conosce ancora la loro reazione. Le dichiarazioni fatte da Rossi danno ragione allo scetticismo con il quale il mondo scientifico internazionale accolse l'annuncio dei due chimici, che il 23 marzo prospettarono la possibilità di avere a portata di mano una fonte inesauribile di energia pulita e a buon mercato.

Secondo Pons, preside della facoltà di chimica dell'università dell'Utah, e Fleischmann, inglese, dell'università di Southampton, con il loro metodo sarebbe possibile con un secchio d'acqua di mare ottenere energia pari a quella fornita da una tonnellata di carbone.

I due sostennero che con un processo elettrochimico attuato dentro un vaso di vetro grande come un barattolo da cucina era possibile spingere due deuteroni (particelle nucleari di deuterio o idrogeno pesante, che abbonda nell'acqua di mare) attraverso un reticolo formato da elettrodi di palladio e platino, ottenendo la fusione di particelle con carica positiva e creando così nuovi atomi.

«Le indicazioni che abbiamo tratto dalle nostre ricerche ci dicono che la scoperta verrà con relativa facilità trasformata in una tecnologia utilizzabile per generare calore e energia», disse all'epoca Pons. Nonostante le critiche subito piovute da tutto il mondo su i due chimici, l'università dell'Utah brevettò l'esperimento Pons-Fleischmann e il governo dello Stato trovò senza indugi 4,3 milioni di dollari per creare «The national cold fusion institute».

⁂

Le dichiarazioni di Rossi sono giunte dopo la visita compiuta all'università la settimana scorsa da un esperto del Cern, il laboratorio europeo per la ricerca nucleare con sede a Ginevra. Si tratta di Douglas Morrison, che ebbe una serie di incontri con gli scienziati di Salt Lake City e dichiarò poi che i tentativi eseguiti in tutto il mondo per duplicare la «fusione fredda» lasciano ben poche speranze che sia fattibile.

28 SEP 89 15:11
R.L. GARWIN

Lawrence Berkeley Laboratory
1 Cyclotron Road Berkeley, California 94720

Building 70A, Room 3307

TEL. (415) 486-5661, FTS 451-5661
FAX: (415) 486-4515
BITNET: NSD@LBL
TELEX: 910-366-2037 Answerback: LBL BERK

FAX TRANSMITTAL
****

TO:
Dr. Richard Garwin
IBM Fellow & Science Advisor to the Director of Research
IBM CORPORATION
P. O. Box 218
YORKTOWN HEIGHTS, NY 10598

FAX NUMBER: 914-945-2141

FROM: Professor Darleane C. Hoffman 70A/3307 Lawrence Berkeley La
Berkeley, CA 94720

DATE: September 2$\overset{8}{0}$, 1989

TOTAL NUMBER OF PAGES INCLUDING COVER PAGE: 8

9-22-39

Search for MeV Ions Produced during Fracture of LiD Crystals

P. B. Price

Physics Department, University of California, Berkeley, CA 94720

Recent experiments have shown[1-5] that the rate of cold fusion of deuterons during either electrolysis or high-pressure deuteration of Pd or Ti is many orders of magnitude lower than claimed[6-8]. It has been conjectured[9,10] (Mayer, F. J., King, J. S., and Reitz, J. R., unpublished; and Ryan, R. et al., unpublished) that fusion, which would occur at vanishingly low rates under static conditions, might occur at detectable rates under dynamic conditions. In particular, if a metal lattice, embrittled by deuteration, were to undergo microfracturing, deuterons might be accelerated in the transient high electric fields across the cracks, reaching energies sufficient to cause fusion. Emission of low-energy ions has been observed during mechanical fracture of $TiD_{0.8}$ (Menlove, H. O. et al., unpublished), and Klyuev et al.[11] have claimed that, during fracture of LiD single crystals, they detected an excess of neutrons above the cosmic-ray background. These results, and earlier claims to have observed electrification[12,13] and emission of low-energy electrons[14,15] and ions[15] during fracture of dielectric crystals, prompted me to see whether energetic protons are emitted during fracture of LiD crystals. My resulting null result casts doubt both on the claim of Klyuev et al. to have seen fusion neutrons and on the conjecture that deuterated Pd or Ti could produce a detectable number of energetic particles as a result of fusion at cracks.

Figure 1 shows the geometry of the experiment. I obtained a ~15 cm^3 single crystal of LiD (grown by M. Delong, Physics Department, University of Utah). I cleaved the crystal vertically along (100) planes into about 10^2 thin plates, with the bottom of the crystal supported 0.9 mm above the surface of a CR-39 track-recording plastic detector. This distance is negligible compared with the range in air of either a 3.03 MeV proton or a

1.01 MeV triton emitted in the fusion reaction d+d → p+t. To eliminate background tracks due to radon decay and cosmic-ray interactions, I etched the CR-39 and located pre-existing tracks just before cleaving the LiD crystal. In this way, as in a previous search for cold fusion in my laboratory[5], the background was reduced to zero. After cleaving the crystal 10^2 times, I re-etched the CR-39 and scanned it for new tracks. There were 9 pre-existing tracks of particles with $Z = 1$ and 2, and no new tracks. The etching conditions were the same as in ref. 5.

Table 1 compares my experiment with that of Klyuev et al.[11] Each fragment of the single crystal of LiD that I cleaved was ~2.5 cm long and 0.4 to 2.5 cm high. However, the ranges of a 3.03 MeV proton and of a 1.01 MeV triton in LiD are only ~0.19 mm and ~0.015 mm, respectively, much shorter than the height of the cleavage crack. Thus, the tritons sample only ~8% as large an area of crack as do protons and can be ignored. We have to take into account not only the solid angle and efficiency for detection but also the surface area of crack from which protons could reach the detector and be recorded. Assuming that fusion products are emitted isotropically and uniformly throughout the cleaved samples, the product of detection efficiency, η, and effective source area, A, is $\langle\eta A\rangle = 0.0057$ cm^2 for protons in my experiment, compared with 0.0023 cm^2 for neutrons in the experiment of Klyuev et al. (In my experiment the cracks ran the full horizontal length of each crystal, ~2.5 cm; the effective height was ~0.019 cm; and the maximum acceptable zenith angle was ~40°; see ref. 5 for a more detailed discussion of the calculation of $\langle\eta A\rangle$.)

Based on the average number of neutrons per fracture reported by Klyuev et al., and taking account of the fact that the production rates of 3 MeV protons and 2.45 MeV neutrons in d-d fusion are about equal, I expected to detect ~64±27 protons per 100 cleavages, whereas I found none. At 90% confidence level, the null result of my search for protons allows one to infer that the number of neutrons per fracture of an area 0.09 cm^2

should be less than ~10^{-2}. If the number of neutrons produced scales with crack area, the upper limit (90% C.L.) becomes one neutron per 9 cm^2.

We can use this limit to test the conjecture that d-d fusion might occur in the transient electric fields across a propagating crack. Let us make the rather extreme assumption, that deuterated Pd or Ti undergoes brittle fracture as readily as does LiD and develops as large an electric field across a crack as does LiD. (The latter seems highly unlikely, since LiD has a remarkably low conductivity at room temperature, ~10^{-23}/ohm-cm.) The upper limit for deuterated Pd or Ti then becomes one neutron generated by fusion for every 9 cm^2 of crack area formed. To account for even the lowest claimed cold fusion yield, ~10^3 neutrons cm^{-3} during an 18 hr run (Menlove, H. O., et al., unpublished), at least 10^4 cm^2 of crack area would have to be generated. These authors claimed that the neutrons often occurred in bursts of up to 250 neutrons, which would require the creation of more than 2500 cm^2 of crack area at one time. This stretches credulity. To attribute the origin of the vastly higher neutron fluences in the original reports of cold fusion to a crack mechanism would require the creation of ~10^{10} cm^2 (ref. 6) and ~10^5 cm^2 (ref. 7) of crack area.

My conclusions are that (a) positive ions such as are detected during fracture of a wide variety of materials are not accelerated to MeV energies; (b) the number of neutrons emitted per cm^2 of crack area in LiD is at least a factor 30 lower than reported in ref. 11; (c) fusion of deuterons accelerated in the electric field across a crack in a deuterated material cannot account for any measurable neutron fluences.

References

1. Gai, M. et al. Nature 340, 29-34 (1989).
2. Lewis, N. S. et al. Nature 340, 525-530 91989).
3. Ewing, R. I. et al. Fusion Technology, in press (1989).
4. Ziegler, J. F. et al. Phys. Rev. Lett. 62, 2929-2932 (1989).
5. Price, P. B. et al. Phys. Rev. Lett., in press (1989).
6. Fleischmann, M., Pons, S., and Hawkins, M. J. Electroanal. Chem. 261, 301-308 (1989).
7. Jones, S. E. et al. Nature, 338, 737-740 (1989).
8. De Ninno, A. et al. Nuovo Cim. 101A, 841-844 (1989).
9. Garwin, R. L. Nature 338, 616-617 (1989).
10. Cohen, J. S., and Davies, J. D. Nature 338, 705-707 (1989).
11. Klyuev, V. A. et al. Sov. Tech. Phys. Lett. 12, 551-552 (1986).
12. Kornfeld, M. I. J. Phys. D 11 1295-1301 (1978).
13. Golovin, Yu. I. et al. Sov. Phys. Solid State 27, 671-674 (1985).
14. Dickinson, J. T. et al. J. Mat. Sci. 16, 2897-2908 (1981).
15. Wolbrandt, J., Linke, E., and Meyer, K. Phys. Stat. Sol. A27, K53-K55 (1975).

ACKNOWLEDGEMENTS I thank Michael Solarz for experimental assistance. The work was supported in part by the National Science Foundation.

Table 1 Comparison of this experiment with that of Klyuev et al.

	Klyuev et al.[11]	This expt.
Effective source area per cleavage	~0.09 cm^2	~0.04 cm^2
Detection efficiency (incl. solid angle)	2.6%	12%
Number of cleavages	several	~10^2
Particle studied	neutrons	protons & tritons
Observed number of particles	0.26±0.11 per fracture	0
No. expected, based on Klyuev et al.	--	54 ± 23

Figure Caption

1. System for recording tracks of protons and tritons from d-d fusion resulting from acceleration of deuterons in the transient electric field across a cleavage crack.

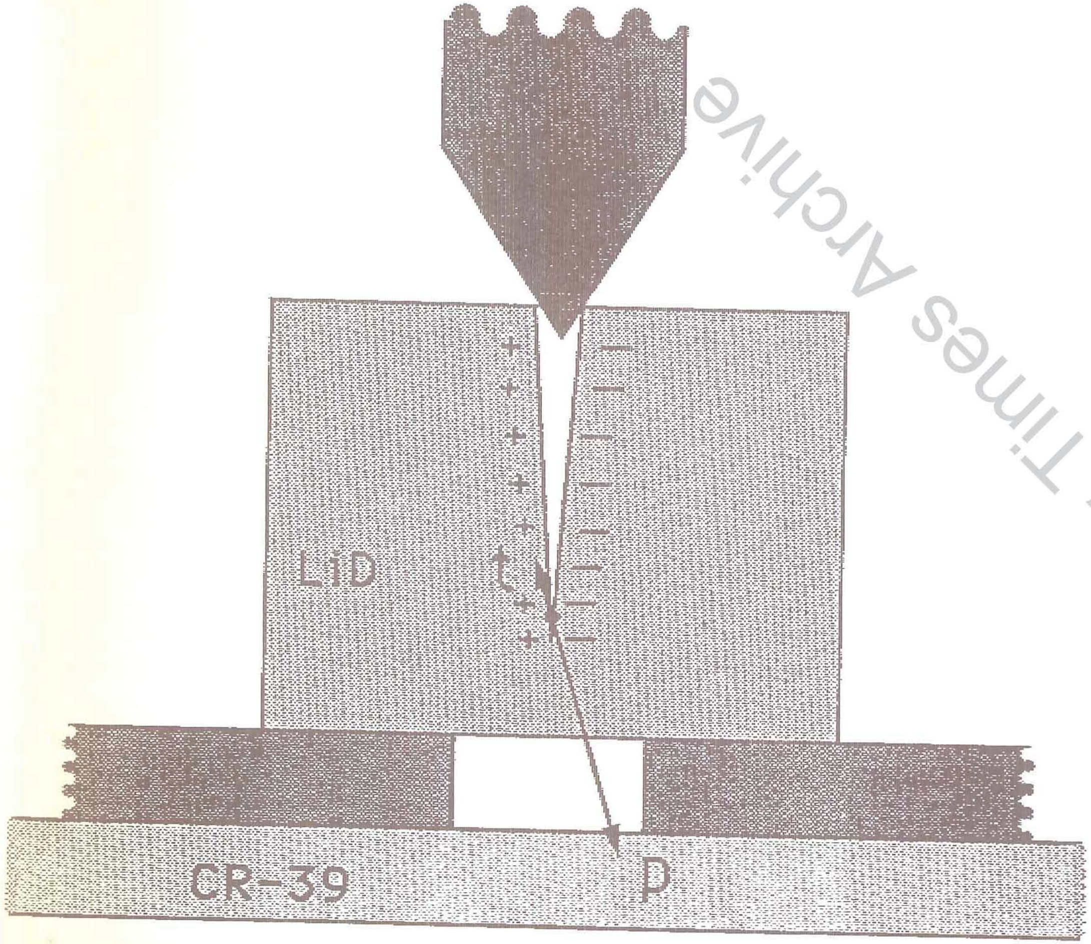


Figure 1

Received: from Csa2.LBL.Gov by IBM.COM (IBM VM SMTP R1.2.1MX) with TCP; Wed, 27 Sep 89 22:34:00 PDT
Date: Wed, 27 Sep 89 22:32:16 PDT
From: hoffman@Csa2.LBL.Gov (Darleane Hoffman)
Message-Id: <890927223216.21c02480@Csa2.LBL.Gov>
Subject: Re: Slightly revised first draft
In-Reply-To: Your message <890924193329.20800170@Csa2.LBL.Gov> dated 24-Sep-1989
To: schiffer%anlphy.bitnet@Csa2.LBL.Gov
cc: jbigelei%sbccmail.bitnet@Csa2.LBL.Gov, rlg2@ibm.com,
koonin%caltech@Csa2.LBL.Gov, hoffman@Csa2.LBL.Gov

To: John Schiffer
From: Darleane Hoffman

Corrections to Table II.
The yield normalized to Jones et al. for Sundqvist et al. should be 0.2 not 2. Also note spelling of Sundqvist.

There should not be an [a] after Porter et al. as they state that they did correct for the geometric collection efficiency and the limited volume of the Pd foil which was sampled using the same method as Price et al.[Pr].

Please replace the first part of my section IV. with the following:

"A few experiments (Po, Pr, Re, Su) to measure the 3 MeV protons and/or the 1 MeV tritons produced in the reaction, D(d,p)T, have been reported; they are summarized in Table II below. A variety of different methods has been used, but the lowest limit on charged-particle production appears to be that set by Price et al.(Pr) using plastic track detectors. Their setup was designed so that the light water control cell matched the heavy water cell as closely as possible. Cathodes of 25-micrometer-thick Pd sheet with a 100 nm Au diffusion barrier evaporated on the side which faced the plastic (CR-39) detector, and anodes of 2 micrometer Pd evaporated on 100 nm Au on microscope slides were used. The light water control cell contained 1 M LiOH and H2O and the other cell contained 1 M LiOD and D2O. Electrolysis was performed for 13 days, and the cathode stoichiometry was determined to be Pd(H,D)0.8. Both cells showed track production rates which agreed and were consistent with the alpha-particle emission rate for native Pd foils due to trace (ppm) impurities of the natural U-238 and Th-232 decay chains; however, no tracks due to protons with energies between 0.2 and 3 MeV or tritons with energies between 0.2 and 1 MeV were found. From these data Price et al. (Pr) set limits on the fusion rate of less than 0.002 per cm3 per second. This value results in an upper limit of 8.3 x 10-26 fusions per dd pair per second. This is about an order of magnitude lower than the limits obtained using Si surface barrier (SSB) techniques.

A limit on the fusion rate of 0.0281 per cm3 per second or 1.2 x 10-24 fusions per dd pair per second was obtained by Zeigler et al. [Zi] using a SSB technique. Porter et al. [Po] used a SSB detector to view the back of a 76 micron thick Pd foil cathode in a heavy water electrolysis cell. They obtained a limit of less than 6 x 10-25 protons per dd pair per sec at the 2 sigma level; chemical analysis of their electrolytes showed no evidence for anomalous increases in tritium concentrations. Sundqvist et al. [Su] also used a SSB technique to detect protons. The detector was placed close to Pd foil cathodes which were thin enough to allow all the protons produced to escape from the foil. All of their runs gave a result of 0 within the statistical errors, resulting in a fusion rate of

(-2.1+/-2.2) x 10-24, if a bulk process is assumed.

Recently, Rehm et al. [Re] have reported using a proportional counter to search for charged particles from electrolytic cells with Pd and Pt electrodes in 0.1 M LiOD in D2O. They obtained an upper limit of 4 x 10-23 fusions per dd pair per second, not as low as the limits using the other methods.

In summary, a variety of experimental techniques has been used in searches for charged particles; all of them set very low o9o5
limits on fusion occuring via the D(d,p)T channel. Most of these results set limits on fusion via this channel that are considerably less than Jones et al.'s [Jo] value of (1.00+/-0.82)x10-23 fusions per dd pair per second for the D(d,n)3He channel obtained from neutron measurements. (Sundqvist et al. calculated the uncertainty for this value.)

The upper limit of Price et al. [Pr] of 8 x 10-26 fusions per dd pair per second is much below the average low rate inferred from the neutron measurements of Jones et al.5 or even those of Menlove et al. [Me]. The extremely low limits which the searches for charged particles (either protons or tritons) place on their production is clearly inconsistent with the reported production of tritium via the cold fusion reaction."

I would also like to add something referring to the recent work of Price [Pr2], which has been submitted to Nature, probably right after the above which says:

"Very recently, Price [Pr2] has cleaved a 15 cc single crystal of LiD vertically along (100) planes into about 100 thin plates, with the bottom of the crystal supported 0.9 mm above the surface of a track-recording plastic detector. Based on the average number of neutrons per fracture reported by Klyuev et al. [Kl], and the nearly equal production rates of 3 MeV protons and 2.45 MeV neutrons in DD fusion reactions, he expected to detect about 64+■-27 protons per 100 cleavages whereas none were found. Assuming the number of neutrons produced scales with crack area, he set an upper limit at the 90% confidence level of one neutron per 9 cm2. In order to account for even the lowest claimed cold fusion yield of about 10exp3 neutrons per cc, at least 10exp4 of crack area would be required. If the much higher neutron fluences reported originally [Fl], [Jo] for cold fusion were to be attributed to a crack mechanism, creation of crack areas of the order of 10exp10 and 10exp5 cm2, respectively, would be required! He concludes "that positive ions such as are detected during fracture of a wide variety of materials are not accelerated to MeV energies; that the number of neutrons emitted per cm2 of crack area in LiD is at least a factor of 30 lower than reported by Klyuev et al. [Kl]; and that fusion of deuterons accelerated in the electric field across a crack in a deuterated material cannot account for any measurable neutron fluences"."

REFERENCES

[Pr] P. B. Price, S. W. Barwick, W. T. Williams, and J. D. Porter, "Search for Energetic Charged Particle Emission from Deuterated Ti and Pd Foils", Phys. Rev. Lett., submitted 7-14-89

[Pr2] P. B. Price, "Search for MeV Ions Produced during Fracture of LiD Cyrstals, September 1989 Preprint, Nature (submitted).

[Zi] J. F. Ziegler, T. H. Zabel, J. J. Cuomo, V. A. Brusic, G. S. Cargill III, E. J. O'Sullivan, and D. A. Marwick, Phys. Rev. Lett. 62, 2929 (1989).

[Po] J. D. Porter, A. A. Shihab-Eldin, H. Bossy, F. J. Echegaray, J. M. Nitschke, S. G. Prussin, J. O. Rasmussen, and M. A. Stoyer, "Limits on Electromagnetic and Particle Emission for Palladium-D2O Electrolyt-

ic Cells", Lawrence Berkeley Laboratory Preprint LBL-27523, July 1989, submitted to J. Fusion Technology.

[Su] B. U. R. Sundqvist, P. Hkansson, A. Hedin, R. V. Bucur, B. Johansson, and R. Wppling, Uppsala University, Sweden, preprint of o9o5 manuscript accepted for publication in Physica Scripta, May 15, 1989.

[Jo] S. E. Jones, E. P. Palmer, J. B. Czirr, D. L. Decker, G. L. Jensen, J. M. Thorne, S. F. Taylor and J. Rafelski, Nature 338, 737 (1989).

[Me] H. O. Menlove, M. M. Fowler, E. Garcia, A. Mayer, M. C. Miller, R. R. Ryan, and S. E. Jones, "Measurement of Neutron Emission from Ti and Pd in Pressurized D2 Gas and D2O Electrolysis Cells", Los Alamos National Laboratory Report LA-UR 89-1974, submitted to Nature, June, 1989.

As to the quotation, I am very fond of it, but our Committee has already been accused of being biased against cold fusion and I'm afraid this will make us appear snide as well--although perhaps that doesn't really matter!

More comments later as soon as I have a chance to read more carefully.

Darleane

Date: Tue, 26 Sep 89 13:00 EDT
From: JBIGELEISEN@SBCCMAIL.BITNET
Subject: Comments on Schiffer Draft of 24 Sept.
To: RLG2@YKTVMV.BITNET
X-VMS-To: in%"RLG2@YKTVMV.BITNET"

State University of New York at Stony Brook
Stony Brook, NY 11794-3400

Jacob Bigeleisen
Professor
Chemistry
516-632-7905
26-Sep-1989 12:57pm EDT

FROM: JBIGELEISEN
TO: Remote Addressee   (_RLG2@YKTVMV.BITNET)
CC: Remote Addressee   (_HOFFMAN@LBL.GOV)
CC: Remote Addressee   (_HUIZENGA@UORCHEM.BITNET)
CC: Remote Addressee   (_KOONIN@CALTECH.BITNET)

SUBJECT: Comments on Schiffer Draft of 24 Sept.

26 September 1989

Dr. John P. Schiffer,
Physics Division,
Building 203,
Argonne National Laboratory,
Argonne, Illinois 60439-4843

Dear John,

It is clear why John Huizenga asked you to coordinate the section on fusion products. It is excellent; I have afew comments. I will not try to deal with the typographical errors.

1. I believe we need to cover Menlove's neutron bursts both from metals in contact with D2 and from his electrolytic cells. This is important not only as one of a number of experiments that give neutrons at low levels, but also it points out the difficulties in detecting low levels of neutrons. This has implications for other programs for which Menlove built these detectors.

2. We need a section on 3He and 4He. Measurements have been made at Livermore, Battelle Northwest and North American Rockwell. Fleischmann and Pons have sent heat producing electrodes to Johnson and Mathey some time ago. There is no word of their findings. The other analysts report less than 10**9 He atoms in the samples provided to them. From the heat burst

and excess heat claims, these electrodes should have about 10**17 He atoms. This would be an appropriate section in which to deal with Schwinger's hypothesis - cold fusion is real, but it comes from the p + d reaction. But where is the 3He?
3. We should supplement the gamma spectrum published by Fleischmann & Pons by an authentic gamma spectrum from neutron capture by protons to give deuterons plus gamma. One can use either the Petrasso spectrum in this region or a spectrum given us by Lewis and Barnes at Cal Tech. An important point here not mentioned in Schiffer's draft is the Fleischmann-Pons spectrum does not have a low energy Compton satellite. I am sending Schiffer a copy of the two spectra. I am sure that the Graphic Arts Division at Argonne can reproduce these to the same scale and then superimpose them.
4. Change reference In from Bombay to Bhabha.
5. Section Vc. The reference is to Scott at ORNL. He does not describe the closed cell explicitly in his memo to Appleton, but it is not ruled out. I actually learned the details of his and all the ORNL work on my visit to ORNL on 12 September. I have sent a separate memo to Alan Bard giving him a summary of the calorimetry. There are no smoking guns.
6. Section Vd. Second paragraph. is lower by 0.6 than the D2O (liquid).
7. Section Vd. The tritium production rate in the Bockris cells (Bockris, I don't know about Kevin Wolf) is > 7x10**9/sec. Thus the secondary neutron yield is > 10**5/sec. Change 10,000 to 100,000 unless you have a lower tritium production rate from Kevin Wolf in the actual cells in which he measured the 1 neutron/sec.
8. Section Vd. Regarding Martin's work. Johnson & Mathey, a major supplier.
9. Section Vd. Change the last sentence in the last paragraph to read: "Additional investigations are desirable.....observed."
10. Tables I and II.The entrance in the header 2 x 10** - 11 neutrons (protons) per DD pair per sec. required by 1 watt of heat production is not clear.
11. The Walling - Simons paper has been published in the Journal of Physical Chemistry.

Jacob Bigeleisen

BITNET copies to:
Garwin, Hoffman, Huizenga, Koonin and Schiffer

Date: Tue, 26 Sep 89 13:57 EDT
From: JBIGELEISEN@SBCCMAIL.BITNET
Subject: Additional Comments
To: RLG2@YKTVMV.BITNET
X-VMS-To: in%"RLG2@YKTVMV.BITNET"

State University of New York at Stony Brook
Stony Brook, NY 11794-3400

Jacob Bigeleisen
Professor
Chemistry
516-632-7905

26-Sep-1989 01:49pm EDT

FROM:	JBIGELEISEN	
TO:	Remote Addressee	(_SCHIFFER@ANLPHY.BITNET)
CC:	Remote Addressee	(_RLG2@YKTVMV.BITNET)
CC:	Remote Addressee	(_HOFFMAN@LBL.GOV)
CC:	Remote Addressee	(_HUIZENGA@UORCHEM.BITNET)
CC:	Remote Addressee	(_KOONIN@CALTECH.BITNET)

SUBJECT: Additional Comments

John:

I believe you need to expand on the Sandia results in Section IIId. This is just not a question of not reproducing the results; the Sandia experiment shows what the problem is with Menlove's bursts. Menlove has not been too receptive to critical analyses of his neutron detection. He was cool and unreceptive to a suggestion from Maurice Goldhaber to replace the 3He with 4He in half of his counters. He said the counters are sealed commercial units. It takes too long to order 4He filled counters. With the great LANL shops he could have buit some 4He counters. By this time he should have been able to have received ones from a commercial vendor.

There is no entry in Table I for the Sandia experiments.

Reference [16] in Appendix IIIc should be changed to [Bi].

JAKE

2 OCT 89 12.92 -R.L. GARWIN-

~~1 SEP 89 10.79 -R.L. GARWIN-~~

Energy Research Advisory Board
to the
United States Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 586-5444

September 25, 1989

Subject: Chairman's July 20 Request for Summaries of Past and Present Cold Fusion Research and August 9 Request for Tritium Production Results

The following have been received to date from the following individuals in response to the above requests:

W. S. Jones, et.al, Brigham Young University (response to August 9 request)
XYZ. D.R. McCracken, AECL (response to August 9 request)

* * * * * *

BEGIN RED SERIES

A. J.F. Holzrichter, LLNL (response to August 9 request)
B. W. Appleton, ORNL (response to July 20 request)
C. D. Manos, PPPL (response to August 9 request)
D. K.I. Thomassen, LLNL (response to July 20 request)
E. M. Danos, NIST (response to July 20 request)
F. R. Jensen, LANL (response to July 20 request)
G. J. Harb & W. Pitt, Brigham Young U. (response to August 9 request)
H. A. Narath, Sandia National Laboratories (response to August 9 request)
I. S. Pons, U. Utah (response to August 9 request)
J. H. Randolph, Westinghouse Savannah River Co. (responses to July 20 and August 9 request)
K. N. Samios, Brookhaven National Laboratory (response to July 20 request)
L. C. White, Naval Research Laboratory (response to July 20 request)
M. H. Law, AT&T Bell Laboratories (response to August 9 request)

Immediately behind this memorandum is a cumulative index.

Bill
William L. Woodard
Panel Secretary

Enclosures

092589. WLW

INDEX

A. Bo U.R. Sundqvist, Uppsala University (response to both requests)
B. W. Scheid, Giessen University (responses to both requests)
C. M.M. Broer, AT&T Bell Laboratories (response to August 9 request)
D. J. Eridon, Naval Research Laboratory (response to August 9 request)
E. Y.E. Kim, Purdue University (response to July 20 request)
F. A Schriesheim, Argonne National Laboratory (response to July 20 request)
G. M.A. Prelas, University of Missouri, Columbia
H. L.R. Greenwood, ANL (response to August 9 request)
I. F. Besenbacher, University of Aarbus (response to July 20 request)
J. N.J.C. Packham (for Bockris), Texas A&M (response to August 9 request)
K. J. Paquette, Atomic Energy of Canada, Ltd.
L. N. Lewis, California Institute of Technology (response to August 9 request)
M. J. Rafelski, University of Arizona (response to August 9 request)
N. P.D. Bond, Brookhaven National Laboratory (response to August 9 request)
O. J.L. Straalsund, Battelle (response to August 9 request)
P. A. Narath, Sandia National Laboratories (response to August 9 request)
Q. W. Appleton, Oak Ridge National Laboratory (response to August 9 request)
R. Texas A&M University (response to August 9 request)
S. T.F. Droege (response to July 20 request)
T. S. Lien, Idaho Operations Office (response to August 9 request)
U. M. Wadsworth, U. Utah (response to August 9 request)
V. J. Farny, Institute of Plasma Physics, Warszaw (response to July 20 request)
W. S. Jones, et.al, Brigham Young University (response to August 9 request)
XYZ. D.R. McCracken, AECL (response to August 9 request)

*   *   *   *   *   *

BEGIN RED SERIES

A. J.F. Holzrichter, LLNL (response to August 9 request)

B. W. Appleton, ORNL (response to July 20 request)

C. D. Manos, PPPL (response to August 9 request)

D. K.I. Thomassen, LLNL (response to July 20 request)

E. M. Danos, NIST (response to July 20 request)

F. R. Jensen, LANL (response to July 20 request)

G. J. Harb & W. Pitt, Brigham Young U. (response to August 9 request)

H. A. Narath, Sandia National Laboratories (response to August 9 request)

I. S. Pons, U. Utah (response to August 9 request)

J. H. Randolph, Westinghouse Savannah River Co. (responses to July 20 and August 9 request

K. N. Samios, Brookhaven National Laboratory (response to July 20 request)

L. C. White, Naval Research Laboratory (response to July 20 request)

M. H. Law, AT&T Bell Laboratories (response to August 9 request)